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R. H. STINCHFIELD, *Editor*

Editorial Office: 1102 16th Street, N. W., Washington 6, D. C.

VOLUME XXXVI NO. 10

TABLE OF CONTENTS, DECEMBER 1952

Evergreen Time 3
Jeff in Holiday Mood

The Leaf Analysis Approach to Crop Nutrition 6
Discussed by M. E. McCollam

The Muellers Conserve Soil 15
C. W. Gee Tells How They Do It

Potash Deficiency of Reforested Pine and Spruce Stands in Northern New York 17
Described by Svend O. Heiberg and Donald P. White

Flue-cured Tobacco Fertilizers of the Future 23
F. W. Parker Makes Some Predictions

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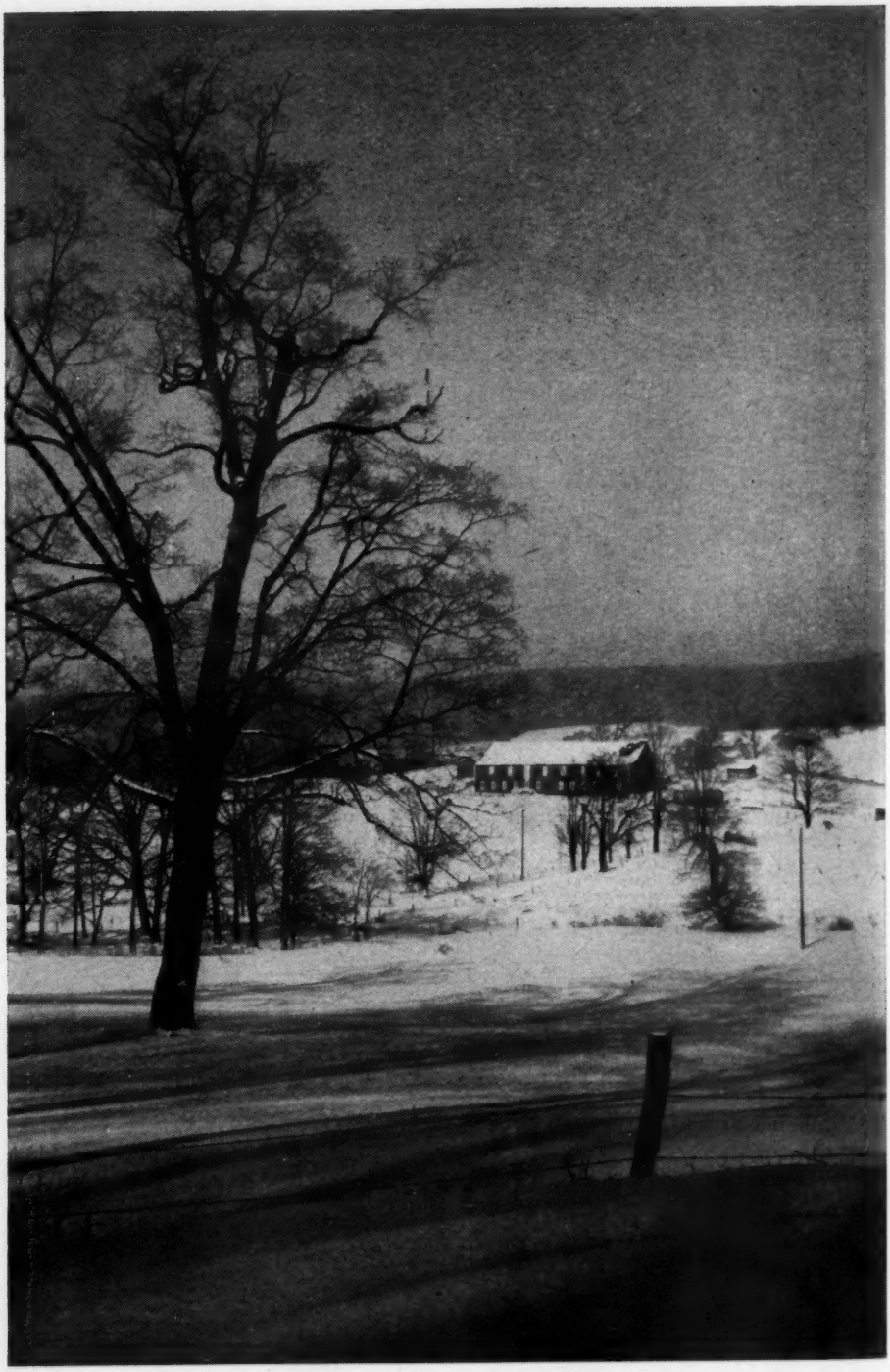

Peace on the Fields

Better Crops with PLANT FOOD

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VOL. XXXVI WASHINGTON, D. C., DECEMBER 1952 No. 10

In salute to . . .

Evergreen Time

Jeff McDermid

GREEN boughs at holiday time and evergreen vistas seen on every rural jaunt during the season when the rest of the world is brown and drab induces one to consider what prime forces we are using today to keep the trees we have and replace those we squandered.

During late fall this season there was an extra heavy autumnal haze cast across the landscape. Much of this gray curtain came direct on the wings of the winds that fanned the forest fires—a multitude of little, scattered fires, and many huge and devastating ones, with but a pitiful handful of trained observers and quenchers organized and able to beat back those searing flames. Many prospective homes and office buildings burned to the ground with the blackened trees. Our ability to find the wooden wherewithal to box and ship the articles of defense destined for distant battlefields was also suffering hard this fall. Few citizens are aware, for example, that during World War II this nation's lumber mills and wood-working industries utilized for the Army and Navy enough board feet of native timber to replace all the wood it takes to build the city of Chicago.

YOU and I of the elder generation were raised when the wealthy timber barons and the wood users of America had their heyday of cutting, slashing, log-driving, sawmilling, and shingle making. More of the open forest lands of greater acreage than today were public lands than is the case at present. Nobody was paying any heed to conservation of the bountiful forest resources, because our grandfathers had to hew the trees and brush away for the sake of sustenance; and there were no state and federal agencies, no schools, no organizations, no

public protective voices raised to defend this basic wealth of ours from total destruction. Had anyone suggested that the future would drive us to set up working partnership agreements as to the cutting, grazing, and management of our private as well as public forests, such a man would have seemed presumptuous and bureaucratic.

Americans are often slow to realize the need to take drastic action to save us from ourselves. Not only is this often true with forest conservation, but it is seen as a necessity where "suitcase" farmers gamble with our precious soils. We now know that soils and water are linked with forests in a vital way which the leaders of our youth were too blind and greedy to consider.

IT'S hard to realize with all the trained foresters we have now that the encyclopedia carried the word "forestry" for the first time in 1902. The establishment of the Forest Service in 1905 will soon have its fiftieth anniversary. The states slowly enacted laws that gave them a better share in the relationships which today are aimed at keeping you and me alert to the necessary sensible forest-using and forest-saving practices so long neglected and abused. It's the appeal to the individual that counts most. If you own even a small woodlot, or go hunting and fishing, or travel to the national forest recreation places, or graze livestock, or buy a few two-by-fours or scantlings, *you* are the one they are after to educate and convince. In conserving our forests and the land and waterways adjacent to them, the idea to remember is that with successful preservation there just "ain't no Santa Claus."

And moreover, here's another clincher—unless you intend to put all the wild livestock and wild fowl snugly inside city zoos for casual peanuts and other handouts, some safeguards must be thrown around their native homelands and birthplaces amid the evergreens and the hardwoods of the open native wilds.

TOO many of the first settlers were far from conservation-minded, to say the least. It almost seems as though many of them figured, like the poor Indian, that only worthwhile trees were to be liquidated. Timber got treated about like the pigeon and the buffalo. It is only in comparatively recent years that men gazed in admiration at the annular rings on a cut stump which showed that a certain pine had been a sapling when Columbus discovered America.

It is true that Plymouth Colony passed an ordinance to prohibit the cutting of timber on colony lands without official sanction. Owing to poor hauling facilities and bad roads or none at all, local shortages occurred near the larger colony towns. These often led to minor restrictions on cutting. William Penn's ordinance required that one acre be left in trees for every five acres slashed away. But it was not until 1710 that any record is seen of community conservation of forests. In that year a tract of about 100 acres owned by Newington, N. H., was set up as a community forest. Records show that this proved a wise investment. For two centuries wood from this preserve was used in local construction, being fashioned into a church, parsonage, town hall, library, bridges, and for fuel to heat public buildings.

History notes another old-time community forest established at Danville, N. H., in 1760. In the opening years of the nineteenth century federal action began to emerge with an eye to forest management. The first known federal forest reservation was taken by the Navy to supply its needed ship timbers of oak. The site of it was on the Santa Rosa peninsula in the Bay of Pensacola, Florida. Both a reservation and a forest experiment station were set up there on 30,000 acres. They failed to pan out because of some political jockeying. The project was dropped in 1830. But in 1831 an act to stop trespass on live oak tracts became the forerunner of present-day laws to pre-

vent timber landtrespass on the public domain.

Egged on by the urgent Naval needs of the days of clipper ships, a timber protection law was enacted in 1871, including the first actual federal appropriation for timber-saving on government lands, amounting to $10,000. The first example of a federal bulletin devoted to trees appeared in a 30-page section of the annual report by the

Agriculture Section in the U. S. Patent Office in the year that the Civil War opened. The early beginning of the present, well-protected system of our national parks occurred in 1872 when the Yellowstone Park was set aside as a federal reservation and a public "pleasuring ground." Maine enacted the initial tree-planting incentive measure in 1872 which gave a 20-year tax exemption for land planted to suitable trees.

Next we come to that interesting era when folks found the East crowded and the land stubborn, causing hordes of settlers to move westward in Conestoga wagons. Congress provided that a homesteader might get a patent on 160 acres of land in the Great Plains region if he agreed to plant 40 acres of each such tract to trees. While some changes in this law followed its original enactment and reduced the terms of the tree subsidy, we can see today many evidences of those little groves and shelter belts in Illinois, Ohio, Indiana, and Missouri. Donald Culross Peattie chose that theme for his interesting book, "The Prairie Grove."

The first scientific society known to have petitioned legislatures for some real forest conservation was the famous American Association for the Advancement of Science. Meeting in 1873 at Portland, Maine, the society named a special committee to look into this matter and to work for suitable legislation to protect the native forests and to cultivate new ones. Finally, in 1875 this action aroused enough special interest to induce a group of far-sighted men to organize the American Forestry Association—just about 100 years after the first signs of timber depreciation began to appear in the settled areas.

IN the face of growing exploitation of our standing timber with no idea of restoration, Congress appropriated $2,000 in 1876 for a look-see into what was left of the original wealth of native woodlands. Commissioner of Agriculture Watts was authorized to appoint an investigator, Dr. Franklin B. Hough, to work on a slim budget. Information that could lead to the formation of a Division of Forestry was also sought at the same time.

At this juncture we got unexpected aid and counsel from two prominent German immigrants, whose long familiarity with the great forest reserves of their homeland taught the folly of the heedless course this young democracy was taking to the ruin of the trees. First of the strong voices to urge federal reservations and scientific handling of forests was the Hon. Carl Schurz of Wisconsin, who became Secretary of the Interior in 1877. He had had a notable career as a general and corps commander during the Civil War, and was among those vigorous patriots who deserted Germany in 1848-49 for a

(*Turn to page* 51)

Fig. 1. Leaf sampling in a vineyard.

The Leaf Analysis Approach To Crop Nutrition

By M. E. McCollam

San Jose, California

THE solution of plant nutrition problems has been approached from two main directions—the soils upon which plants grow and the plants themselves. In considering the plant approach, scientists have for many years made chemical analyses of plants and plant parts. In the past few decades, however, these chemical studies have been directed more and more toward assigning a significance to the various levels of nutrient elements in plants as they relate to sick and healthy plants.

As an instance, if it could be established that the leaves from healthy, high-producing sugar beet plants generally have 1,000 ppm or more of phosphate-phosphorus on a dry weight basis, whereas, those from certain stunted and low-yielding plants have 500 ppm or less, it might be possible to use this information as a basis for locating phosphorus-deficient sugar beet areas by taking sugar beet leaf samples and interpreting their chemical analysis with reference to the level of phosphorus. Similarly, the leaves from certain healthy fruit trees, shown by chemical analysis to contain 2.5% potassium, might be compared chemically with leaves of other ailing trees of the same kind which showed only 0.8% potassium. With suitable previous study of potassium levels in leaves of fruit trees as a background, this case could be interpreted as indicating that the sick trees were in need of potash fertilizer.

Actually, a very large volume of re-

search work of this kind has now been accomplished with many crop plants, including fruit crops, field crops, and vegetables. Although leaf analysis research is still going on and gaining in volume, it is now possible to put the leaf analysis or plant analysis approach to crop nutrition problems to practical use and make intelligent interpretations of the analytical results.

There are several terms used in the field of leaf analysis which need to be clarified in order to avoid confusion. The term "foliar analysis" is in common use and denotes essentially the same procedure as leaf analysis. In trying to arrive at the identity of a nutritional disturbance in plants, the nature of certain observational symptoms on the plant parts may be taken into consideration. These are called "plant food deficiency symptoms," or "hunger signs." In the broad sense, when attempting to "analyze" a nutritional problem, these visual symptoms are a part of leaf analysis or foliar analysis. In the more restricted sense, however, leaf analysis and foliar analysis refer to the study and interpretation of plant nutritional problems from data obtained through chemical analysis of the leaves of plants.

Because the leaf is not always the part of the plant from which a sample for chemical analysis is obtained, several research workers in this field prefer to call the method "plant analysis." Undoubtedly, as time goes on it may be found that parts of the plant other than leaves are indicative of the nutrient status of a particular crop, and this term may have more justification than at present. Currently, the mid-part of the stems of alfalfa plants is being used to indicate the nutrient status of this crop. This sampling operation, while proven to be satisfactory, is done as much for convenience as for physiological reasons. In studying excesses of sodium in tree crops, it has been found in some cases that the analysis of root samples is a better basis for interpreting the condition than leaf samples.

The fact remains, however, that leaves, thus far, have been most extensively used in this diagnostic method, and leaf analysis appears to be the most appropriate term.

The term "petiole analysis" is also occasionally used, because this is the

Fig. 2. Location of leaf taken when sampling the potato crop. ***(Western Washington Experiment Station photograph.)***

plant part determined to be most significant in arriving at the nutrient status of the crop. Since the petiole, in the botanical sense is the "leaf stem" and therefore a leaf part, this designation would appear to be adding a rather superfluous term to this field of plant science.

From the standpoint of plant physiology, the leaf would appear to be the best indicator of nutrient status. It is the most vital part in the nutritional processes of the plant. In the leaf the nutrients are gathered and combined for redistribution throughout the plant. It is the breathing and manufacturing organ of the plant. If the plant cannot get enough of any one of the essential mineral elements from the soil, life processes are crippled, and the crop is reduced in yield and quality. The analysis of the leaf content, therefore, should reflect the ability of the crop to grow and produce.

The thinking of most workers in the leaf analysis field is that it is a method which gives extremely valuable information on nutritional problems, and therefore enables a more accurate diagnosis to be made. A leaf analysis expresses an integration of the whole situation under which the plant is growing. The plant itself is the best indicator of the availability of the elements in the soil vital to its nutrition, since it is the plant which extracts those elements from the soil and utilizes them. If any set of environmental conditions under which the plant is growing is favorable or unfavorable to the extraction of nutrient elements, the plant will reflect this and leaf analysis will confirm it.

The time and method of taking leaf samples have been the subjects of much research, and certain procedures can now be followed with a high degree of assurance. It is generally agreed that leaf samples taken too early or too late in the season do not give a true picture of the nutrient supply situation under which the plant is growing throughout the season. For instance, late in the season, calcium, magnesium, sodium, and chlorine increase in the leaf, while potassium, nitrogen, and phosphorus are decreasing. Early in the season some of the nutrients are particularly high in the leaf. Therefore, it has been found that leaf samples taken around mid-season are most indicative of the nutrient status of the crop. Most of the critical nutrient levels in leaves of crop plants thus far studied have been established with reference to this mid-season sampling period.

Leaf-sampling Methods

Although there are a number of apparently satisfactory techniques for actually gathering the leaf samples, it is of highest importance to gather only leaves of the same approximate age. Consequently, leaves must be taken from the same relative position on all plant samples. As an example, on deciduous fruit trees spur leaves may be taken, or leaves near the basal position on the current season's growth may be taken. The important point is that if spur leaves are taken, all subsequent leaf samples should be collected from the spur position so that a standard sampling method is followed and the most accurate interpretation of the leaf analysis results is possible.

The number of leaves to be taken per sample should be enough for proper laboratory procedure in preparing and analyzing the sample. If a reference sample is kept for further analytical examination, the original sample must be large enough to provide for this, too. For most species of fruit trees, 100 leaves are sufficient. With small leaves such as the olive, double this number will be needed. Leaf petioles are used for the leaf analysis in the case of grapes and sugar beets. A satisfactory sample size for these crops has been found to be 80 grape petioles and 40 beet petioles.

A guide for leaf-sampling procedure on a number of crops has been compiled in the accompanying Table I.

TABLE I.—GUIDE TO PART OF PLANT AND TIME TO TAKE IT FOR LEAF SAMPLING

CROP	PART OR PLANT TO SAMPLE	TIME OF SAMPLING*
FRUITS AND NUTS		
Apple	Matured leaves on spurs, or leaves near base of current year's growth	June 15 to July 15
Apricot	Matured leaves on spurs, or leaves near base of current year's growth	June 1 to July 15
Almond	Matured leaves on spurs, or leaves near base of current year's growth	June 1 to July 15
Filbert	Matured leaves from median section of current season's growth	Sept. 15 to Sept. 30 (Ore.)
Prune	Matured leaves on spurs, or leaves near base of current year's growth	June 15 to July 15
Plum	Matured leaves on spurs, or leaves near base of current year's growth	June 15 to July 15
Peach	Matured leaves near base of current year's growth	June 15 to July 30
Pear	Matured leaves on spurs, or leaves near base of current year's growth	June 15 to July 15
Olive	Matured leaves from median position on last flush of growth	March or August
Walnut	Terminal leaflet from a matured leaf	July 15 to August 15
CITRUS FRUITS		
Lemon	Matured leaf from last flush of growth	May to July
Orange	Matured leaf behind a young fruit	July to October
VINE AND BERRIES		
Grape	A young matured leaf, usually the fifth to seventh leaf from tip of new cane. Use only petioles	July 1 to 30 (One month earlier for early districts)
Raspberry	A young matured leaf, usually fourth to sixth leaf from tip of new cane. Use leaf petioles. If magnesium is to be determined, keep leaf blades for this purpose	June 15 to July 15 (Wash.)
FIELD CROPS		
Alfalfa	Middle 1/3 of stem. Use stalk for analysis	A few days before cutting
Barley	Leaf blades from matured leaf near top of plant	April 15 to May 15
Beet (sugar)	A matured leaf. Avoid old outer leaves and young inside leaves. Use only petiole of leaf	Midseason (June-July in many areas)
Clover (ladino)	Pluck leaves at regular intervals across field. Use only leaf stalk from mature leaves for analysis	May-June

TABLE I (CONTINUED)

CROP	PART OR PLANT TO SAMPLE	TIME OF SAMPLING*
TRUCK CROPS		
Beet (table)	A matured leaf. Avoid old outer leaves and young inside leaves. Use only petiole of leaf	Midseason (June in many areas)
Celery	Petiole of matured leaf	Plants 12" to 15" tall
Lettuce	Midrib from wrapper leaf	At heading
Pea (canning)	Leaf blades or petioles taken at 3rd node from top of plant	When plants have 6 to 9 nodes (Wash.)
Potato	The fourth or fifth leaf from top of plant. Use petioles for analysis	35 days from planting (Wash.) 35 to 45 days from emergence (Calif.)
Tomato	The first matured leaf down from the tip of the plant (fourth from tip)	During early bloom

* All sampling dates are for California conditions, unless otherwise noted.

Critical Nutrient Levels and Interpretation

Once the chemical analysis of the leaf sample is made, the content of nutrients found to be present must be referred to a certain standard of deficiency for each element called the critical level, after which an interpretation can be made. The critical level of a nutrient element can be defined as the range in concentrations at which plant growth (and yield) is restricted as compared to the growth of the same kind of plant at higher nutrient level.

Although we apparently have not progressed far enough in our leaf analysis research to be sure of the range of the critical level of nutrients for most of the crops studied, we are reasonably sure of the nutrient level at which deficiency symptoms are readily seen on the plant. Above this level is another range, which should be included in the range of the critical level, at which we are likely to get some improvement in the growth or yield.

Phosphorus and Potash

We have chosen to separate these two levels in the accompanying Tables II and III which set forth leaf analysis levels at which symptoms of phosphorus and potash deficiency appear, levels at which these two nutrients may likely be deficient in supply, and levels which represent a sufficiency.

Nitrogen

In the chemical analysis of leaf samples for nitrogen, the common practice is to report total nitrogen content in the case of most crops. The presence of nitrates can be determined and interpreted in the case of some crops, but not all. The nitrate nitrogen test on such crops as cereals, clovers, sugar beets, grapes, and many truck crops can be very useful in showing their nitrogen status during the growing season. The diphenylamine test for nitrates is quite useful as a *rapid method* for finding nitrogen deficiencies on fresh plant material in the field, and on dried plant material in the laboratory. When a dark blue color develops immediately upon contact of the diphenylamine reagent with the freshly cut surface of the plant material, a sufficiency of nitrogen is indicated. A deficiency is indicated when only a faint blue color appears, usually taking a few minutes to show up. In these samples low in

TABLE II.—SIGNIFICANCE OF LEAF PHOSPHORUS READINGS ON SAMPLES SELECTED AS IN TABLE I

CROP	SUFFICIENT P	RANGE FOR TRIAL P	DEFICIENCY SYMPTOMS P
FRUITS AND NUTS	(D. M. Basis)	(D. M. Basis)	(D. M. Basis)
Apple	Above 0.10%	Below 0.10%	Not found
Apricot	Above 0.10%	Below 0.10%	Not found
Almond	Above 0.10%	Below 0.10%	Not found
Filbert	Above 0.15%	Below 0.15%	Not found
Prune	Above 0.10%	Below 0.10%	Not found
Plum	Above 0.10%	Below 0.10%	Not found
Peach	Above 0.10%	Below 0.10%	Not found
Pear	Above 0.10%	Below 0.10%	Not found
Olive	Above 0.10%	Below 0.10%	Not found
Walnut	Above 0.10%	Below 0.10%	Not found
CITRUS FRUITS			
Lemon	Above 0.15%	Below 0.10%	Below 0.07%
Orange	Above 0.10%	Below 0.10%	Not found
VINES AND BERRIES			
*Grape	Above 500 ppm	Below 500 ppm	Not found
Raspberry	Above 0.30%	Below 0.30%	Below 0.30%
TRUCK CROPS			
*Beet (table)	Above 1,000 ppm	Below 1,000 ppm	Below 500 ppm
*Celery	Above 1,000 ppm	Below 1,000 ppm	Below 500 ppm
*Lettuce	Above 1,000 ppm	Below 1,000 ppm	Below 500 ppm
*Pea (canning)	Above 2,000 ppm	Below 2,000 ppm	Below 1,200 ppm
*Potato	Above 1,500 ppm Above 3,500 ppm	Below 1,200 ppm Below 3,500 ppm	Below 400 ppm (Calif.) Below 1,500 ppm (Wash.)
*Tomato	Above 1,000 ppm	Below 1,000 ppm	Below 500 ppm
FIELD CROPS			
*Alfalfa	Above 1,000 ppm	Below 1,000 ppm	Below 500 ppm
*Barley	Above 1,000 ppm	Below 1,000 ppm	Below 500 ppm
*Beet (sugar)	Above 1,000 ppm	Below 1,000 ppm	Below 500 ppm
*Clover	Above 1,000 ppm	Below 1,000 ppm	Below 500 ppm

* Phosphorus readings in these crops are ppm phosphate phosphorus.

TABLE III.—SIGNIFICANCE OF LEAF POTASSIUM READINGS ON SAMPLES SELECTED AS IN TABLE I

CROP	SUFFICIENT K	RANGE FOR TRIAL K	DEFICIENCY SYMPTOMS K
FRUITS AND NUTS	(D. M. Basis)	(D. M. Basis)	(D. M. Basis)
Apple	Above 1.00%	Below 1.00%	Below 0.50%
Apricot	Above 2.00%	Below 1.50%	Below 1.00%
Almond	Above 0.75%	Below 0.75%	Below 0.50%
Filbert	Above 0.75%	Below 0.75%	Not found
Prune	Above 1.50%	Below 1.00%	Below 0.75%
Plum	Above 1.50%	Below 1.00%	Below 0.75%
Peach	Above 1.50%	Below 1.00%	Below 0.75%
Pear	Above 1.00%	Below 0.75%	Below 0.50%
Olive	Above 0.75%	Below 0.50%	Below 0.30%
Walnut	Above 1.00%	Below 1.00%	Below 0.50%
CITRUS FRUITS			
Lemon	Above 0.75%	Below 0.75%	Below 0.35%
Orange	Above 0.75%	Below 0.75%	Below 0.35%
VINES AND BERRIES			
Grape	Above 1.00%	Below 1.00%	Below 0.50%
Raspberry	Above 1.50%	Below 1.00%	Below 1.00%
TRUCK CROPS			
Beet (table)	Above 1.50%	Below 1.50%	Below 1.10%
Celery	Above 1.50%	Below 1.50%	Below 0.75%
Lettuce	Above 1.50%	Below 1.50%	Below 0.75%
Potato	Above 9.0% Above 11.0%	Below 9.0% Below 11.0%	Below 5.0% (Calif.) Below 6.0% (Wash.)
Pea (canning)	Above 1.20%	Below 1.20%	Below 0.75%
Tomato	Above 1.50%	Below 1.00%	Below 0.50%
FIELD CROPS			
Alfalfa	Above 1.50%	Below 1.50%	Below 0.75%
Barley	Above 1.00%	Below 1.00%	Below 0.50%
Beet (sugar)	Above 1.50%	Below 1.50%	Below 1.00%
Clover (ladino)	Above 1.50%	Below 1.50%	Below 0.50%

Note: Excessive sodium (Na) or chlorine (Cl) in the leaf, above 0.50%, will make the interpretation of nutrient deficiencies more difficult.

Fig. 3. Grinding the dried leaf samples preparatory to chemical analysis.

nitrate nitrogen, usually a brown color gradually develops which obscures the faint blue color.

Laboratory methods for the determination of nitrate nitrogen on dried plant material have been described by Albert Ulrich in the book "Diagnostic Techniques for Soils and Crops." Methods utilizing fresh plant material, such as that used by O. A. Lorenz at the University of California, can also be used to determine nitrate nitrogen status.

The accompanying Table IV will be of assistance in interpreting leaf analysis readings of nitrate nitrogen.

Determinations other than nitrate nitrogen expressed as % N on a dry-matter basis, while commonly made on leaf material, have not been extensively interpreted on the basis of critical level or deficiency level. However, in the case of tree crops it is felt that leaf nitrogen readings below 1.5% N indicate a need for nitrogen. At the Western Washington Experiment Station,

TABLE IV.—SIGNIFICANCE OF PLANT ANALYSIS READINGS FOR NITRATE-N ON SAMPLES SELECTED AS IN TABLE I

CROP	SUFFICIENT	POSSIBLY NEEDED	DEFICIENT
Grape	Over 500 ppm	Under 500 ppm	0 ppm
Beet (sugar)	Over 2,000 ppm	Under 2,000 ppm	0 ppm
*Celery	Over 500 ppm	200–500 ppm	Less than 200 ppm
*Lettuce	Over 500 ppm	200–500 ppm	Less than 200 ppm
*Potato	Over 1,000 ppm	Under 800 ppm	500 ppm
*Tomato	Over 500 ppm	Under 500 ppm	200 ppm

Note: Dry-weight basis unless noted otherwise.
* Extract of fresh material used for analysis.

F. T. Tremblay has stated in connection with leaf nitrogen levels in the potato crop that the leaves should contain 6.5% N for maximum yields. (Potato leaves sampled 35 days from planting.) The data of O. A. Lorenz of the University of California support a leaf content figure of 2.5% N or below as a deficiency for the potato crop, and a figure of 3.0% N and above as sufficient. In this case potato plants were sampled 35 to 45 days *after emergence*.

Practical Uses of Leaf Analysis

Fertilizer Recommendations—Just as soil testing has offered a basis for making fertilizer recommendations, leaf analysis is now being used successfully in making more effective fertilizer recommendations. Leaf analysis is being employed by several agricultural service laboratories in California as a means of solving crop nutritional problems for growers. Its value is being recognized by growers not only as a means of identifying nutritional troubles in their crops, but as a means of knowing their nutritional status so that serious deficiencies can be prevented.

Careful sampling, careful analytical work, field experience, and intelligent interpretations are all just as important with the leaf analysis method as with the soil testing method. Leaf analysis has the advantage of being a much less laborious method in the collection of adequate samples. It also has the advantage of appraising the nutrition of the plant itself rather than only the soil upon which it is growing.

Crops which occupy the land for several years, such as tree fruits, grapes, berries, alfalfa, and clovers, are particularly adapted to leaf analysis since the results can be applied to these crops the following season.

In the case of annual crops, the results of leaf analysis can be applied the following season if the same crop again is to occupy the same land, or it may be practical to apply the results when the particular crop sampled again occupies the same land in the crop rotation.

Surveys of Plant Nutrient Status—Nutrient surveys by means of leaf analysis are very helpful in locating areas of deficiency. Such areas may be located by this method on large individual farm plantings or in more extended agricultural areas devoted to a certain crop.

(*Turn to page* 43)

Fig. 4. Problems of confirming leaf symptoms caused by nutritional deficiencies or excesses can be solved through leaf analysis. Left—normal apricot leaves; center—leaf symptoms of potassium deficiency; right—leaf symptoms of sodium excess.

The Muellers Conserve Soil

By C. W. Gee

Soil Conservation Service, U. S. Department of Agriculture, Milwaukee, Wisconsin

FROM a windswept hilltop where they sleep away the years in an old family burial ground, the forefathers of Walter J. Mueller could look down today upon a strange pattern of farming which has spread over the land they once tilled. Gone are the virgin forests, leveled by their own axes as they hewed this farm out of the wilderness. Gone, too, are the great square fields down which they pridefully turned the long, straight furrow.

In the place of these things today are smaller tracts of land with curving fence boundaries which fit closely to the natural pattern of the hillside. Lush fields of brome-alfalfa grow on ground the first Muellers used for corn. Here and there over the 200-acre farm near Freeburg, Illinois, are long gentle ridges of earth which modern farmers know as terraces.

These would be strange things, indeed, to old John Mueller who bought the farm for $1.25 an acre back in 1830, since these are the marks of modern conservation farming still unknown in his time. Yet it is only because of conservation farming that the land is still owned and farmed by a member of the Mueller family. Here was Walter J. Mueller's answer to the problem of keeping the farm boy on the land.

"I would never have been able to keep my son on the farm if I had not gone in for soil conservation farming and had continued to plow up and down the hill," Walter Mueller declared. "He would never have gone through what my father and I put up with fighting those ditches.

"I was doing general farming, raising cattle and hogs. I was working the land just the way my grandfather laid it out and just as my father had taught me to farm. We had big fields and we plowed up hill and down. We were losing plenty of soil.

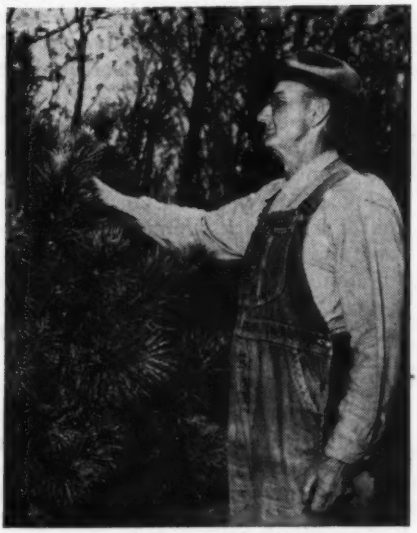

Fig. 1. Walter Mueller inspects his pine seedlings.

"Every spring and fall we would put in several days hauling tons of straw to fill in the ditches. Filling ditches is hard work and it's discouraging. My son, Kenneth, and I were both getting tired of farming.

"We were always having trouble with repairs on our farm machinery and besides that we could see that we were losing our soil. There was no way of getting by without hauling straw and it had been the same when father was alive. In addition, our crop yields were dropping."

The change came soon after farmers in this part of southwestern Illinois or-

ganized the Shiloh-O'Fallon Soil Conservation District. This was the first district in Illinois and was organized in 1938.

"I had read a little about soil conservation before that," Walter Mueller said, "but I didn't know how to go about it. About the time they were organizing the district they held some educational meetings for farmers. The first meeting was held in the Freeberg high school auditorium and I was right there. I knew I had to do something about the farm or get off it. The district got me started."

After Shiloh-O'Fallon had been organized, the farmers asked the U. S. Soil Conservation Service to assign them a soil conservation technician. And it was Morris Fonda, now of Detroit and president of the Soil Conservation Society of America, who gave Walter Mueller his first technical assistance in developing a complete soil conservation plan.

Walter Mueller and his son, Kenneth, began developing their new plan gradually. The first year they did a little contouring and seeded some pasture and grass waterways. By the end of the second year they had about 41 acres on the contour, had put in 2,000 feet of terrace outlets, fertilized 15 acres, planted 2.3 acres of trees, had built a half mile of terraces, and were strip-cropping 46 acres.

"Farmers seldom apply a complete plan right away," Walter Mueller explained. "These conservation plans are not compulsory in any way and you build into them gradually. Many farmers make changes in their plans from time to time as they see a chance for improvement. That's what we did."

The Mueller plan, which was No. 33 for the district, is now 12 years old. Walter Mueller moved to Freeberg 10 years ago but his son liked the soil conservation idea and has carried on with the work. The father and son team operate the land on a partnership basis and it is a rare day, indeed, that does not find the elder Mueller, now 64, doing some work at the farm.

They have 143 acres of land under cultivation and a 40-acre improved woodlot. They have planted 2,600 black locusts, now mature enough to supply all of their post needs, and have surrounded the grove with 400 shortleaf pine and a multiflora rose fence.

(*Turn to page* 44)

Fig. 2. One terrace narrowly missed the ancient Mueller burial place.

Potash Deficiency of Reforested Pine and Spruce Stands In Northern New York[1]

By Svend O. Heiberg and Donald P. White

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SERIOUS nutrient deficiencies that may be encountered under certain ecological conditions in connection with the re-establishment of forests on old fields in New York were investigated. It was demonstrated that these deficiencies could be corrected, at least in part, by applications of forest debris, forest humus, and potash fertilizers. In addition some light was thrown upon certain aspects of the nutrition of some tree species commonly used for reforestation.

Experimental Site

On a 120-acre, almost flat sand plain on Pack Forest, Warren County, N. Y., formed during the glacial period as a sand terrace in a glacial lake (6), forest plantations of various species were established in 1928 and succeeding years. The area was probably cleared between 1800 and 1850 when forest lands near the Husdon River were lumbered heavily and most level plowable land was farmed. No remnants of the original vegetation exist today, but on similar habitats mixtures of *Pinus strobus* and *Tsuga canadensis* with some *Picea rubens* are found as dominant vegetation, with a ground cover including *Cornus canadensis, Gaultheria procumbens, Linnaea borealis, Maianthemum canadense, Oxalis Acetosella, Trientalis americana, Trillium undulatum, Vaccinium canadense,* and *V. pennsylvanicum.*

At the time of planting the area was almost abandoned for agricultural purposes. On the south and west edge of the terrace water and wind erosion had started at several places. One erosion gully was about 400 feet long with a depth of up to 30 feet; the greatest width was 100 feet.

A complete vegetational analysis was not made in 1928 when the planting of introduced forest trees began. The vegetation was sparse, however, indicating a decidedly infertile habitat, and much bare ground was visible. Generally throughout the area the following species occurred: *Polytrichum commune, Andropogon furcatus, Spirea latifolia, Cladonia* sp., *Ambrosia artemisiifolia, Fragaria* sp., with a few scattered *Juniperus communis, Betula papyrifera,* and *Prunus pennsylvanica.*

The soil profile indicates numerous cultivations of the area. A sharp line of demarkation shows between a 5- to 8-inch deep blackish brown horizon (the old plow zone) and a 10- to 14-inch deep strong brown horizon which very gradually blends into the light yellowish brown substratum. Coarse sand with occasional rounded gravel up to 1 inch in diameter constitutes the texture throughout the profile. The organic matter in the "plowed" horizon varies between 4 and 5%. The acidity of this horizon ranges between pH

Reprinted from Soil Science Society of America Proceedings (1950), Vol. 15, 1951.

[1] Contribution from the Department of Silviculture, College of Forestry, State University of New York, Syracuse, N. Y.

5.0-5.5. Mechanical analysis of the P-horizon shows a sand content of 89%, a silt content of 6.4%, and a coarse and fine clay content of 0.8 and 3.8%, respectively.

The earliest plantings included pure *Pinus resinosa* established in half-acre plots of varying spacing from 3 feet by 3 feet to 10 feet by 10 feet. Later plantings consisted of *Pinus strobus, Pinus banksiana, Pinus sylvestris* of various provenances, *Picea glauca, Picea abies,* and smaller samples of *Larix kaempferi* mostly in mixtures with other species. In addition two compartments of 10 and 15 acres, respectively, were planted to *Pinus resinosa* with some admixtures of *Pinus sylvestris* and *Pinus banksiana.* The same species were used in planting up the edges of the slopes leading to the plain.

Deficiency Symptoms

When the early plantings were only 5 or 6 years old retardation of growth was observed. No diseases connected with this stagnation could be discovered at the time, nor have any been detected during the past 18 years during which time the problem has been considered. The symptoms appear as follows:

1. General chlorosis followed by browning and finally dying of needles and in extreme cases death of the tree.
2. Decreased height and diameter growth.
3. Decrease in the number of years that the needles persist on the tree.
4. Shortening of the needles.

The species reacted, as could be expected, with individual variations due to their species characteristics. *Pinus resinosa,* a species of only slight deviation capacity,[2] exhibited general stagnation with little difference in deficiency symptoms from tree to tree. Only a single tree of this species has been observed dying. *Pinus strobus* showed considerable variation from individual to individual. Dying or dead trees occurred adjacent to trees that still exhibited considerable height growth. A general "tufted" appearance due to the short tufts of the current year's needles was quite characteristic. *Picea glauca* showed even more pronounced symptoms than *Pinus strobus.* Many trees died, and large cone crops were produced on trees that were only a few feet in height. *Picea abies* also exhibited pronounced deficiency symptoms.

Only *Pinus mugo* did not appear to show any visible signs of starvation. *Pinus sylvestris* and *Pinus banksiana* indicated only slight chlorosis just before the plantations closed. The larches suffered so much from frost and animal injury that it was difficult to evaluate to what extent they too exhibited symptoms similar to the pines and the spruces.

Slash Applications

In an effort to alleviate this condition, fresh logging slash consisting mostly of top loppings from a *Pinus strobus* cutting area was scattered between the trees on a section of the stagnating *Pinus resinosa* plantation. The slash almost covered the ground although bare ground was visible on about 10% of the area. The first slash application in plantations was made in May 1934.

The reaction to slash was immediate and rather vigorous. The color of the needles improved markedly even during the first summer, and the annual height growth increased the following year and appeared to increase in proportion to the vigor and the enlargement of leaf surface.

Several slash plots using both coniferous and hardwood slash were established in other plantations including *Pinus strobus, Picea glauca,* and *Picea abies* with the same result as with *Pinus resinosa,* namely, immediate and vig-

[2] The capacity of a species to vary in form and growth habits as well as the ability to differentiate into crown classes.

orus recovery. No difference could be noticed between the effect of hardwood slash from a cutting in an *Acer saccharum* stand and slash from a *Pinus resinosa-Pinus strobus* logging area (4).

It was first thought that the beneficial influence of slash was primarily due to the mulching effect upon the sandy soil. Therefore a controlled experiment was conducted on 1/10-acre sample plots of stagnating *Pinus resinosa*. One plot was mulched with ordinary 3-in thick insulating glass wood, another was covered with slash, while a third was left untreated. Moisture and temperature measurements of the soil were made on the three plots during one growing season. These indicated that the glass wool preserved moisture and leveled temperatures in a similar or a slightly greater degree than slash. However, glass wool, in contrast to slash, did not have any measurable effect upon the growth of the stagnating red pines. This experiment indicated that the mulching effect of the slash was of no consequence for the growth of the pines but rather that slash added to the soil some beneficial substance that was readily soluble and quickly assimilated by the tree roots. After 5-10 years the beneficial effect of the slash application was no longer as pronounced as at first, and so far it is hard to estimate how long the effect will last.

Fig. 1. Response of red pine to fertilization with KCl: left—control, right 200 lbs. of KCl per acre applied 7 years previously. Both trees same height at time of application.

Humus Applications

Other plots were established consisting of humus applications to the soil before planting. Organic matter, composed primarily of the humus layer from a thick greasy mor collected under an old *Pinus strobus-Tsuga canadensis* stand, was evenly scattered to a depth of about 2 inches on a plot on the sand plain and then well spaded in with the old plowed layer. An adjacent area was also spaded but no humus was added. On these areas *Pinus resinosa, Pinus strobus, Picea glauca,* and *Picea rubens* were planted 2 feet by 2 feet in pure blocks in the spring of 1935.

After a few years of adjustment to the site all the species planted on the humus area showed normal color, needle length, and growth while the species planted without humus gradually entered into a stagnating condition. On the *Pinus strobus,* and more particularly on the *Picea glauca* and *P. rubens* plots many trees were actually dying. It is striking to note that the border trees in the plots that were not treated with humus are growing better than those in the interior. In the humus plots the inside trees whose roots have access to humus on all sides are growing far better, in spite of the very close spacing, than the outside trees in the same plot which have access to soil mixed with humus on only one side. Viewed in cross-section the crowns of the treated plot present a convex appearance whereas the untreated plots show a concave appearance.

It is also interesting to note *Maianthemum canadense, Coptis trifolia, Linnaea borealis, Trientalis americana,* and *Mitchella repens,* all species completely foreign to the present plant communities on the desert-like sand plain but now introduced with the humus and flourishing in the shade of the young but dense *Pinus resinosa.*

Including the 1949 growing season, the mean height of *Pinus resinosa* in the humus plot (excluding the border rows) was 14.7 feet as contrasted to 7.2 feet for those in the untreated plot. Corresponding heights for *Pinus strobus* were 9.9 feet and 5.2 feet, for *Picea glauca* 6.6 feet and 4.4 feet, and for *Picea rubens* 6.1 feet and 1.8 feet.

Chemical Fertilizer Applications

The response to humus, as well as the previously established value of natural organic materials such as hardwood and coniferous slash, suggested that some nutrient substance or substances were being supplied in these organic applications. Moreover, whatever this essential substance was, it was evidently lacking in the soil to a serious degree. In this connection it should be mentioned that the *Pinus resinosa* planted along the slopes and edges of the plain are normal and vigorous, showing none of the symptoms of stagnation. This coupled with the fact that the "border effect" is quite pronounced on the entire plain, points strongly to a severe depletion in soil nutrients as a result of agricultural use. The results of these experiments suggested chemical fertilizer trials. First a plot of stagnating *Pinus resinosa* was treated with a complete 5-10-5 fertilizer at a rate of 500 lbs. per acre. This resulted in a strong growth response.

Next six $\frac{1}{10}$-acre plots were established in stagnating red pine plantations using the following treatments (rates based on 1-acre applications): 100 lbs. ammonium sulfate, 500 lbs. calcium oxide, 200 lbs. potassium chloride, 200 lbs. tricalcium phosphate, 300 lbs. sodium nitrate, and untreated. All fertilizers used were chemically pure in order to minimize any effect of trace elements and were applied in the form of dry powder or granules. Care was taken to broadcast the fertilizer evenly over the plots. This treatment was made in May 1943 before any height growth had taken place and presumably while abundant root growth was going on.

A height growth response was observed on only the sodium nitrate and the potassium chloride plots. However, the reaction was far greater to potassium chloride than to sodium nitrate. On the potassium plot, the new foliage acquired a healthy green color, the needles were longer, and the height growth increased vigorously (Fig. 1). Height growth also increased considerably on the sodium nitrate plot, but the new needles were not noticeably longer and the color did not improve appreciably. A typical nitrogen response, namely production of luxuriant green leaves, was not obtained. The other plot fertilized with nitrogen, the ammonium sulfate plot, showed no response whatsoever. This suggested that the increased

growth on the sodium nitrate plot might be a reaction to the sodium ion rather than to nitrogen. With certain agricultural plants it has been observed that sodium may replace potassium to a limited extent (5).

In any case, the potassium reaction was strong and clear cut in every respect. The mean annual height growth from the year of application to and including 1949 increased 104% on the potassium plot (Fig. 2) while the response to sodium nitrate was 41%. None of the other plots showed a significant increase in height growth over the control plots (Fig. 3).

Fig. 2. Increased height growth of red pine as a result of application of 200 lbs. of KCl per acre. Finger points to height of tree at time of application.

One very interesting observation on the potassium plot should be mentioned. During the winter 1944-45 snow with a crust on top permitted snowshoe hares (*Lepus americanus americanus*) to reach high enough to eat buds, needles, and bark on two or three of the lowest live sidebranches. It was striking that the hares fed on buds and bark on the potassium plot in preference to the surrounding plots. A tally of damaged trees showed that 88% of the trees on the potassium plot had been nibbled one or more times whereas only 3% of the trees on the control plot had been damaged at all. When fecal pellets were collected by random sampling, it was found that there were 12 times more pellets on the potassium plot than on the control (292 versus 26 pounds, dry wt., per acre).

The hares undoubtedly were finding something in the buds and bark of the potassium fertilized trees that they did not find in the trees outside the potassium plot.

The entire fertilization experiment was repeated in May 1946, except that the amount of ammonium sulfate was increased from a rate of 100 lbs. per acre to 200 lbs. That of tricalcium phosphate was increased from 200 lbs. per acre to 300 lbs. and a plot with potassium sulfate at 200 lbs. per acre was added. In addition, one plot was thinned by 30% of the number of stems, and the cut trees were removed and distributed evenly between the rows of an adjacent plot. A third plot was subdivided; one-half was treated with fresh logging slash from a healthy *Pinus resinosa* stand and the other half with logging slash from a healthy *Pinus strobus* stand.

The results of this new series of fertilizer plots as revealed during the past four growing seasons check exactly

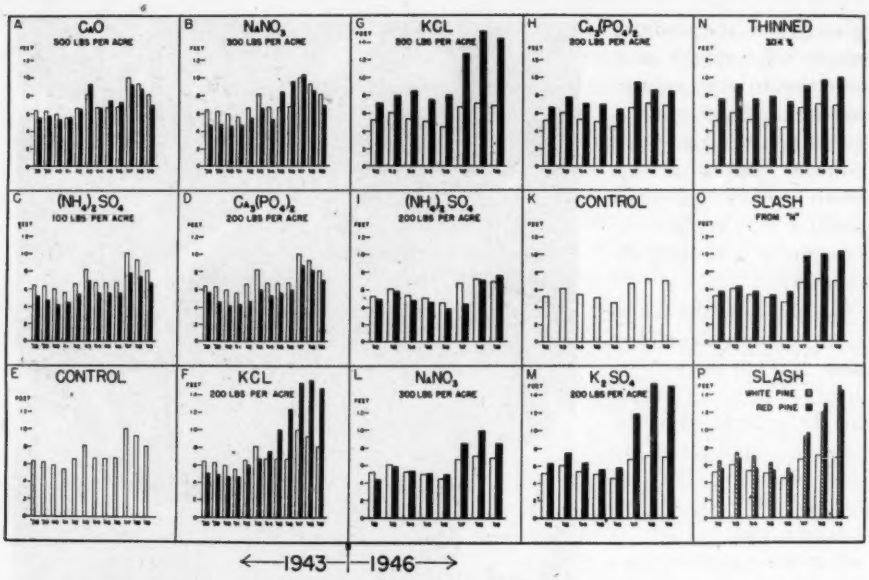
A CaO 500 LBS PER ACRE
B NaNO3 300 LBS PER ACRE
G KCL 300 LBS PER ACRE
H Ca3(PO4)2 300 LBS PER ACRE
N THINNED 30% %
C (NH4)2SO4 100 LBS PER ACRE
D Ca3(PO4)2 200 LBS PER ACRE
I (NH4)2SO4 200 LBS PER ACRE
K CONTROL
O SLASH FROM "N"
E CONTROL
F KCL 200 LBS PER ACRE
L NaNO3 300 LBS PER ACRE
M K2SO4 200 LBS PER ACRE
P SLASH WHITE PINE
RED PINE
1943
1946

Fig. 3. Mean annual height growth response of red pine to various treatments. Open bars, control. Solid bars, treatments.

with those obtained from the 1943 experiment (Fig. 3). The increased amounts of ammonium and phosphate gave no reaction, sodium nitrate showed some increase in height growth, and both potassium plots, the chloride and the sulfate, produced a strong reaction in color, vigor, and height growth. Slash from healthy stands gave a vigorous reaction whereas slash from starving stands gave but slight color and growth response. No measurable response resulted from thinning.

From these results one may conclude that the soil described is deficient in potassium for the growth of *Pinus resinosa* and certain other species commonly used in forest plantations. Furthermore it is significant that severe stagnation of *Pinus resinosa* may be relieved quickly by applications of small amounts of potassium in easily soluble form.

Several additional plots have been established during 1948 and 1949. These include application at the rates of 50, 100, 200, and 300 lbs. of muriate of potash per acre in order to determine the most economical application.

Stagnating *Picea abies* and *P. glauca* were fertilized in May 1949 at the rate of 200 lbs. of muriate of potash per acre. Strong color reaction was observed during the first growing season following application, and it was observed in May 1950, one year after application, that elongation and development of the buds were more than one week advanced on the fertilized plot as compared to the control.

It is too early to make growth trend measurements of these plots, but chemical analyses have been made as will be discussed below.

Chemical Analysis of Needle Tissue and Soil

For chemical analysis of needle tissue, samples were collected during the second and third weeks in September 1949. Needles were obtained from the third whorl from the top on the north side of the tree. Needles were taken from at least three typical trees in each plot and separated by needle age. Pine needles were stripped from the stem in the field, whereas the spruce needles were collected with stems and stripped after drying.

(*Turn to page* 46)

Flue-cured Tobacco Fertilizers Of the Future[1]

By F. W. Parker

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MAJOR changes in fertilizers for flue-cured tobacco can be expected in the near future. These fertilizers will be better than the present standard grades, and the farmer's tobacco fertilizer bill will be substantially lower.

The prospective changes in fertilizers will be based on results of three different but related lines of research, namely:

1. Studies on the plant-nutrient requirements of flue-cured tobacco in relation to yield and quality,
2. Studies of the fertility of soils used to produce tobacco, and
3. Investigations on the composition, quality, and technology of tobacco fertilizers.

Each of the three lines of investigations will be considered briefly before discussing tobacco fertilizers of the future.

Plant-Nutrient Requirements

The Virginia Agricultural Experiment Station (4) conducted a very thorough study of the absorption of plant nutrients by tobacco in 1939 and 1940. The crops were grown on Granville sandy loam at Chatham, Virginia. They received a 3-10-6 fertilizer at the rate of 900 pounds per acre. The average yield of 36 plots was 1,090 pounds of leaf and 404 pounds of stalk per acre. The yield and composition of the crops were determined at four stages of growth, 21, 35, 49, and 63 days after transplanting.

The Virginia investigators found that the 1,494 pounds of leaf and stalk contained 30 pounds of nitrogen, 9 pounds of phosphorus (P_2O_5), 54 pounds of potassium (K_2O), 43 pounds of calcium (CaO), 11 pounds of magnesium (MgO), and 22 pounds of Sulfur (SO_3). The phosphorus content is low in comparison to constituents other than magnesium. Potassium is higher than any other nutrient. A high potassium content is essential for high-quality leaf. Calcium, magnesium, and sulfur are often called secondary elements but from the standpoint of plant composition and essentiality for growth, they are just as important as nutrients as nitrogen, phosphorus, and potassium. Definite provision must be made for their addition in the fertilizer or otherwise in the soil-improvement program.

The study of the time of nutrient absorption by the crop showed that the plants absorbed only 6 per cent of their nitrogen in the first 3 weeks and 8 per cent in the last 2 weeks. Eighty-four per cent of the nitrogen was absorbed in 4 weeks—21 to 49 days after transplanting. The other plant nutrients were absorbed somewhat more slowly at first, and absorption continued later in the growing period than in the case of nitrogen. Since the absorption pattern was similar for phosphorus, potassium, calcium, magnesium, and sul-

[1] Reprinted from COMMERCIAL FERTILIZER, March 1952.

fur, the percentage data have been averaged. Only 3 per cent of these nutrient elements was absorbed in the first 3 weeks, 69 per cent in the next 4 weeks, and 27 per cent in the last 2 weeks of growth.

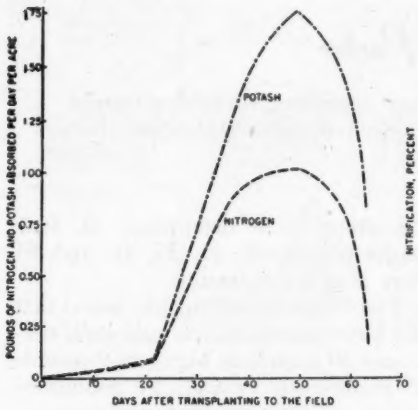


Fig. 1. Rate of absorption of nitrogen and potash by flue-cured tobacco.

Figure 1 shows the daily absorption of nitrogen and of potassium during the 63-day growth period. Note the very high rate of nitrogen absorption in the 30 to 55-day period. Potassium absorption was highest during the 33 to 60-day period and was still at the rate of 1.0 pound per day on the 60th day. The ideal fertilizer would be one that would supplement the soil in supplying the nutrients in the quantity and at the time needed by the crop.

It is apparent from the Virginia data that large quantities of available nitrogen and other nutrients are utilized during the 3 to 7-week period. An abundance of minerals, especially potassium, is essential throughout the entire growing period, but leaf quality will be improved by the development of a slight deficiency of nitrogen during the last weeks of growth. While nutrient uptake is low the first 3 weeks, a good supply of all nutrients in the limited root zone is essential for the rapid development of the young plant.

A comparison between the quantity of nutrients in a tobacco crop and that supplied in current fertilizer practice indicates that the fertilizer program may not be well balanced. Table I shows the estimated quantity of each nutrient required for production of a 1,500-pound crop of good-quality leaf. The nutrient content of roots and stalks and of the leaf is shown separately. The former are left in the field, and a portion of nutrients may be used by subsequent crops. The table also shows the quantity of the same nutrients applied in 1,200 pounds of an average 3-9-6 fertilizer. The last column shows the difference between the nutrient content of the leaf and the quantity applied. There is a reasonably good balance between additions and removal of nitrogen, potassium, and magnesium. On the other hand, phosphorus additions are 15 times the quantity removed, calcium and sulfur additions are 4 and 10 times the quantity re-

TABLE I.—NUTRIENT CONTENT OF FLUE-CURED TOBACCO, ADDITIONS IN FERTILIZER AND NET REMOVAL—1,500 LBS. LEAF PER ACRE.

Nutrient element	Entire crop Lb.	Stalks and roots Lb.	Removed in leaf Lb.	Added in 1200 lb. 3–9–6 Lb.	Net Addition [1] Lb.
Nitrogen (N)	51	18	33	36	+ 3
Phosphorus (P_2O_5)	12	5	7	108	+101
Potassium (K_2O)	103	53	50	72	+ 22
Calcium (CaO)	69	22	47	204	+157
Magnesium (MgO)	26	10	16	24	+ 8
Sulfur (SO_3)	36	15	21	210	+189

[1] Column 5 minus column 4.

moved by the leaf crop. If the comparison is made between the nutrient content of the entire crop and additions in the fertilizer, it still seems probable that the latter carries excessive amounts of phosphorus, calcium, and sulfur. It would appear, therefore, that the possibility of reducing the applications of phosphorus, calcium, and sulfur should be considered. In doing this, however, allowances must be made for differences in efficiency of utilization and in the quantity that might be supplied by the soil.

Soil Fertility

All of the flue-cured tobacco-producing states operate soil-testing laboratories and have accumulated a great deal of information on the fertility of soils being used for tobacco production. Results on 11,868 samples of tobacco soils examined by the North Carolina Soil Testing Laboratory in 1949-50 (6) are summarized in Table II. This study certainly gives the best information available on the fertility of tobacco soils in North Carolina.

The organic content of 81 per cent of the tobacco soils is very low or low. Only 7 per cent are rated high or very high. Most of these soils, therefore, will not provide much nitrogen for the crop. Its requirements must be met with fertilizer. This is fortunate in some respects for it makes possible the production of tobacco of low nitrogen content, one of the essentials of quality in flue-cured tobacco. Extensive experiments have shown that on soils low in organic matter, 36 to 40 pounds of nitrogen in the fertilizer will give a good yield of high-quality leaf. More nitrogen will increase yield but may reduce quality and value per acre.

The level of available phosphorus in soils planted to tobacco is usually very high. Eighty-two per cent of all soil samples fall in the very high or high group with respect to available phosphorus. Only 11 per cent were classed as low or very low. The high available phosphorus level is the direct result of long-continued fertilization with relatively high phosphorus fertilizers. The 101 pounds of phosphorus (P_2O_5) not removed in the crop (Table I) remain in the soil. They are not lost by leaching. When excess phosphorus applications are repeated frequently the amount accumulated becomes quite large. Many investigations, including recent studies with radioactive phosphorus, clearly demonstrate that a portion of the residual phosphorus is available to later crops. As the amount of residual phosphorus accumulates, it finally reaches a level where crops no longer respond to heavy phosphorus fertilization. That is the

TABLE II.—FERTILITY OF NORTH CAROLINA TOBACCO SOILS.

Component	Per cent of 11,868 samples testing—			High	Very high
	Very low	Low	Medium		
Organic Matter	51	30	12	4	3
Phosphorus	3	8	7	18	64
Potassium	5	46	32	9	8
Calcium	7	21	70	2	0
	Per cent in pH range				
	5.0 or less	5.1–5.5	5.6–6.0	6.1–6.5	6.6 or above
	7	46	38	8	1

situation on older tobacco soils, especially in the Coastal Plain. It is estimated (3) that a 50-per cent reduction in the phosphorus fertilization of tobacco would only reduce production in North Carolina by 0.7 per cent. Most of that reduction would be on the small acreage where the soils tested are very low, low, or medium in available phosphorus. The same estimates indicate that complete elimination of phosphorus would reduce yields 17 per cent. It is clearly evident, therefore, that the rate of phosphorus fertilization might be reduced. On the other hand, applications are needed for early vigorous growth of the transplant before it develops a vigorous root system and to maintain high yields. The rate of application should exceed the rate of crop removal so that soil improvement may continue.

Seventy-eight per cent of the North Carolina tobacco-soil samples were low or medium in available potassium. Only 17 per cent were high or very high. It is evident, therefore, that despite rather heavy and frequent fertilization, potassium, unlike phosphorus, does not accumulate in those soils. This is due to the large quantity of potassium removed by the crop and some loss by leaching. Liberal potassium fertilization, therefore, must be continued. Experimental results from several states indicate that for good yields of high-quality leaf, the fertilizer should supply 70 to 100 pounds of potassium (K_2O) per acre.

The calcium status of these soils is relatively good—70 per cent are medium in calcium and only 7 per cent are very low. Likewise, the pH status is generally satisfactory—84 per cent of all soil samples were between pH 5.0 and 6.0. A higher pH is undesirable as it tends to increase tobacco diseases. Only 12 per cent of the soils need liming, and a rate of 1,000 to 2,000 pounds of limestone per acre is sufficient.

The North Carolina soil data, as well as the data on plant requirements for nutrients, indicate that the quantity of phosphorus, calcium, and sulfur in tobacco fertilizers might be reduced. Less extensive soil test data from other states tend to confirm this conclusion.

Fertilizer Composition and Quality

The standard tobacco fertilizer is 3-9-6 and contains 2 per cent magnesium (MgO), not more than 3 per cent chlorine (Cl), and with about one-third of the nitrogen derived from natural organic materials. The phosphorus is from superphosphate, potassium from potassium chloride and potassium sulfate, and nitrogen is from ammonium sulfate and ammonia solutions in addition to the natural organics. The 3-9-6 tobacco fertilizer, containing less than 20 units of plant-food, is the lowest-grade fertilizer that is now sold in large tonnage. Approximately 850,000 tons were sold in 1950-51, chiefly in four states—Virginia, North Carolina, South Carolina, and Georgia.

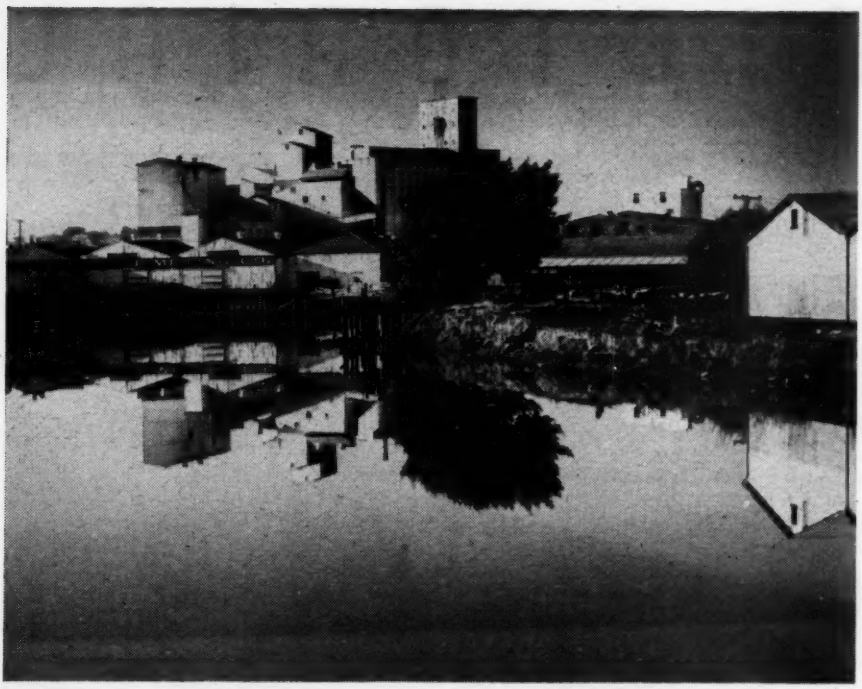
There has been a long-standing demand that a portion of the nitrogen in tobacco fertilizers be in natural organic forms. As a measure of the nitrogen in these forms, it is customary to guarantee the water-insoluble nitrogen content of tobacco fertilizers. Natural organic materials vary widely in composition and nitrogen availability. It seemed advisable, therefore, to study the quality of water-insoluble nitrogen in a large number of representative samples of tobacco fertilizers. Such a study was made on 168 official samples furnished by cooperating state fertilizer-control officials (2).

The results are shown in Figure 2. As an average of all samples, the potential fertilizer efficiency of the water-insoluble nitrogen was only one-half the efficiency of the water-soluble nitrogen of ammonium sulfate. The quality of the insoluble nitrogen varied from good in fertilizers from Georgia to very poor in the Virginia samples. The indications are that the decline in

(*Turn to page* 40)

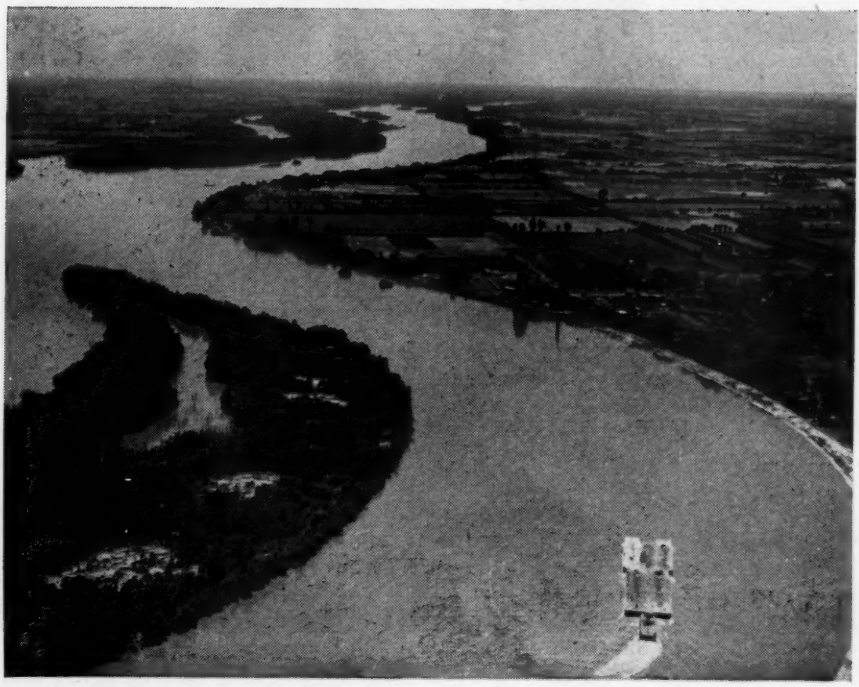
PICTORIAL

Easier Than Shoveling!



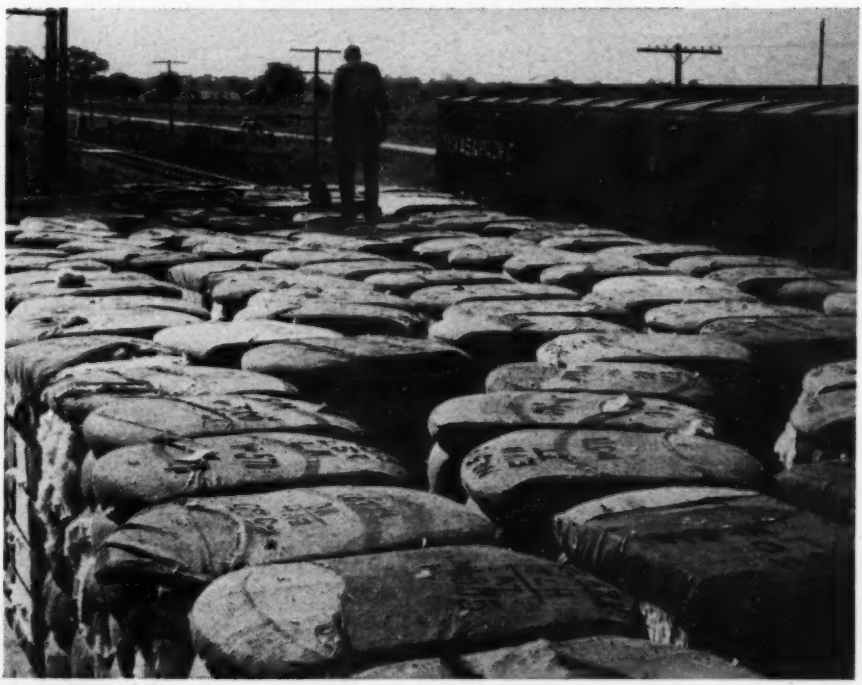
Above: A mirror of industry, Petaluma, California.

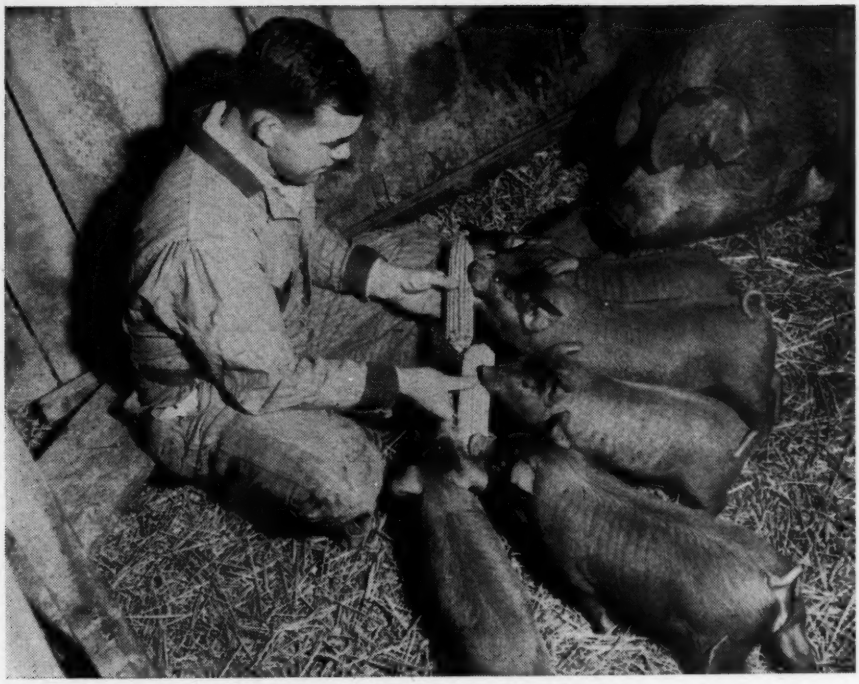
Below: Grain barges moving down the Mississippi.



Above: The pasture is good while the snow stays high.

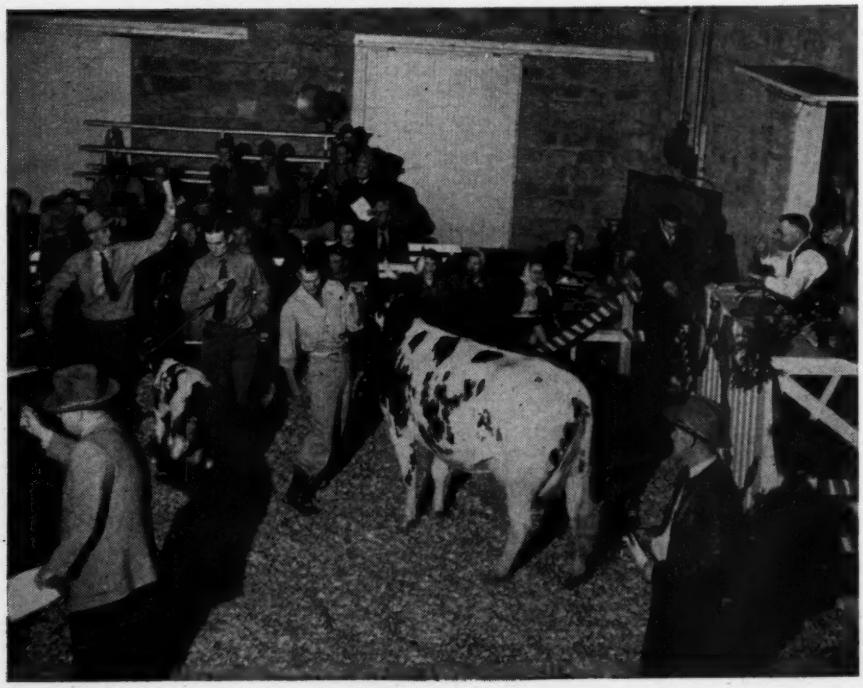
Below: Plenty of shirttails on this railroad dock.





Above: An initiation to an important diet item.

Below: Going—Going—Going—Do I hear anyone say—



The Editors Talk

The Year's End

Again, American agriculture is ending a year with an almost record production. The worries of floods, droughts, and other jeopardies are over, and we find the Bureau of Agricultural Economics of the U. S. Department of Agriculture estimating the second largest crop on record—only 2½% below the 1948 peak. With livestock output above any past year, total farm production is setting a new high.

As in any over-all picture, there must be spots of dissatisfaction. There are those whose production was drastically cut through no fault of their own. Prices received by farmers are on a downward trend, but still average only 1% below parity. On the other hand, prices paid by farmers for commodities have shown small declines in each of the last three months.

Coming back to the over-all picture, the Nation as a whole cannot but feel a keen satisfaction and faith in American agriculture. Increasing population and a limitation to arable land present problems to be met in the future. To meet these will be new fields of research on production and utilization of farm products. Coupled with the "know-how" and resourcefulness of its farmers, this technology gives cause for a continuance of the Nation's trust in its agriculture to meet its emergencies.

Our Cover Picture

Trees are plants, and like all plants, need adequate supplies of carbon dioxide, water, and minerals for healthy growth. Symptoms of mineral deficiencies have been identified on many of the cultivated tree crops, such as apples, peaches, cherries, and prunes. This month we are pleased to present in our cover illustration a potash deficiency symptom on white spruce. The picture was provided by Professors Heiberg and White of the College of Forestry, State University of New York, Syracuse, whose article discussing this deficiency is also to be found in this issue.

According to the authors, the white spruce branches illustrated were collected in May 1952 and comprise the last four years' growth on a lateral branch. These branches came from typical trees in a 25-year-old plantation. Before treatment, the entire stand showed the stunted growth and poor color illustrated by the branch on the right from the untreated part of the plantation. The branch on the left shows the improvement in growth and color achieved on a part of the plantation in three growing seasons following the initial spring fertilization of 200 lbs. per acre of muriate of potash (0-0-60) supplemented by an additional 100 lbs. per acre one growing season before the photographs were taken by Professor Heiberg.

In his book, Forest Soils and Forest Growth, Dr. S. A. Wilde of the University of Wisconsin has this to say about the role of potash: "Potassium speeds up the

assimilation of carbon dioxide and is important in the formation and utilization of sugar and starch in plants, synthesis of proteins, and cell division. Under conditions of reduced sunlight, an ample supply of potassium partly makes up for this deficiency. Potassium is largely concentrated in the active regions of plants, viz., young leaves and needles, buds, and root tips.

"Deficiency of potash leads to the development of weak seedlings with a stunted root system and with soft and sappy leaves. In time, the leaves may become dull and scorched; they age prematurely, become bronzed, and die at the tips or along the edges.

"The addition of potassium fertilizers increases the assimilation of carbon dioxide, facilitates the intake of water, and increases the utilization of nitrogen. This, in turn, increases the rate of growth and vigor of trees. Of particular importance is the influence of potash in counteracting the harmful effect of excessive nitrogen. Potash fertilizers in proper amounts seem to be especially effective in reducing root rot of older seedlings. Because resistance of seedlings to frost is directly related to the content of sugar, potash plays an outstanding part in the production of hardy nursery stock."

Dr. Wilde also says: "The application of fertilizers in forestry aims to accomplish a dual purpose: first, to maintain an adequate level of fertility in permanently cropped soils of forest nurseries; second, to correct nutrient deficiencies in soils supporting plantations or natural stands. During the past decade, foresters have made remarkable progress in the use of fertilizers in forest nurseries; in this phase of fertilizer practice silviculture has attained as high a level of efficiency as found today in agronomy. At the same time, the use of fertilizers outside of nursery beds is still in need of additional research."

With an annual gross value of all timber products estimated at 20 billion dollars per year, the need for such research assumes considerable importance.

Season Average Prices Received by Farmers for Specified Commodities *

Crop Year	Cotton Cents per lb. Aug.-July	Tobacco Cents per lb.	Potatoes Cents per bu. July-June	Sweet Potatoes Cents per bu. July-June	Corn Cents per bu. Oct.-Sept.	Wheat Cents per bu. July-June	Hay [1] Dollars per ton July-June	Cottonseed Dollars per ton July-June	Truck Crops ....
Av. Aug. 1909–July 1914....	12.4	10.0	69.7	87.8	64.2	88.4	11.87	22.55	....
1926.....	12.5	17.9	131.4	117.4	74.5	121.7	13.24	22.04	....
1927.....	20.2	20.7	101.9	109.0	85.0	119.0	10.29	34.83	....
1928.....	18.0	20.0	53.2	118.0	84.0	99.8	11.22	34.17	....
1929.....	16.8	18.3	131.6	117.1	79.9	103.6	10.90	30.92	....
1930.....	9.5	12.8	91.2	108.1	59.8	67.1	11.06	22.04	....
1931.....	5.7	8.2	46.0	72.6	32.0	39.0	8.69	8.97	....
1932.....	6.5	10.5	38.0	54.2	31.9	38.2	6.20	10.33	....
1933.....	10.2	13.0	82.4	69.4	52.2	74.4	8.09	12.88	....
1934.....	12.4	21.3	44.6	79.8	81.5	84.8	13.20	33.00	....
1935.....	11.1	18.4	59.3	70.3	65.5	83.2	7.52	30.54	....
1936.....	12.4	23.6	114.2	92.9	104.4	102.5	11.20	33.36	....
1937.....	8.4	20.4	52.9	78.0	51.8	96.2	8.74	19.51	....
1938.....	8.6	19.6	55.7	69.8	48.6	56.2	6.78	21.79	....
1939.....	9.1	15.4	69.7	73.4	56.8	69.1	7.94	21.17	....
1940.....	9.9	16.0	54.1	85.4	61.8	68.2	7.59	21.73	....
1941.....	17.0	26.4	80.8	92.2	75.1	94.4	9.70	47.65	....
1942.....	19.0	36.9	117.0	118.0	91.7	110.0	10.80	45.61	....
1943.....	19.9	40.5	131.0	206.0	112.0	136.0	14.80	52.10	....
1944.....	20.7	42.0	150.0	190.0	109.0	141.0	16.50	52.70	....
1945.....	22.5	36.6	143.0	204.0	127.0	150.0	15.10	51.10	....
1946.....	32.6	38.2	124.0	218.0	156.0	191.0	16.70	72.00	....
1947.....	31.9	38.0	162.0	217.0	216.0	229.0	17.60	85.90	....
1948.....	30.4	48.2	155.0	222.0	129.0	200.0	18.45	67.20	....
1949.....	28.6	45.9	128.0	214.0	124.0	188.0	16.50	43.40	....
1950.....	40.1	51.6	91.6	173.0	153.0	200.0	16.70	86.50	....
1951									
November...	41.00	50.0	174.0	280.0	162.0	219.0	18.35	72.70	....
December....	40.34	51.0	192.0	305.0	169.0	222.0	19.65	71.50	....
1952									
January.....	38.70	46.2	207.0	347.0	168.0	220.0	20.75	70.10	....
February....	37.25	33.8	205.0	357.0	166.0	218.0	20.65	67.10	....
March.....	36.72	23.5	216.0	383.0	165.0	220.0	20.35	61.50	....
April.....	37.30	15.0	231.0	416.0	168.0	218.0	20.05	60.80	....
May.....	36.08	43.5	264.0	433.0	170.0	213.0	18.65	60.80	....
June.....	38.02	44.0	310.0	436.0	173.0	206.0	17.05	61.90	....
July.....	37.02	42.0	274.0	446.0	173.0	198.0	17.25	71.00	....
August.....	37.92	48.8	278.0	410.0	173.0	204.0	19.35	69.80	....
September...	39.17	51.0	222.0	335.0	171.0	209.0	20.25	69.60	....
October.....	37.03	50.9	211.0	294.0	153.0	207.0	20.85	70.70	....
Index Numbers (Aug. 1909—July 1914 = 100)									
1926.....	101	179	189	134	116	138	112	98	139
1927.....	163	207	146	124	132	135	87	154	127
1928.....	145	200	76	134	131	113	95	152	154
1929.....	135	183	189	133	124	117	92	137	137
1930.....	77	128	131	123	93	76	93	98	129
1931.....	46	82	66	83	50	44	73	40	115
1932.....	52	105	55	62	50	43	52	46	102
1933.....	82	130	118	79	81	84	68	57	91
1934.....	100	213	64	91	127	96	111	146	95
1935.....	90	184	85	80	102	94	63	135	119
1936.....	100	236	164	106	163	116	94	148	104
1937.....	68	204	76	89	81	109	74	87	110
1938.....	69	196	80	79	76	64	57	97	88
1939.....	78	154	100	84	88	78	67	94	91
1940.....	80	160	78	97	96	77	64	96	111
1941.....	137	264	116	105	117	107	82	211	129
1942.....	153	369	168	134	143	124	91	202	163
1943.....	160	405	188	235	174	154	125	231	245
1944.....	167	420	214	216	170	160	139	234	212
1945.....	181	366	205	232	198	170	127	227	207
1946.....	263	382	178	248	212	209	141	319	182
1947.....	257	380	232	248	336	259	148	381	226
1948.....	245	482	222	253	201	226	155	298	214
1949.....	231	459	184	244	193	213	139	192	201
1950.....	323	516	131	197	238	226	141	384	185
1951									
November...	331	500	250	319	252	248	155	322	249
December....	325	510	277	347	263	251	166	317	331
1952									
January.....	312	462	297	395	262	249	175	311	337
February....	300	338	294	407	259	247	174	298	217
March.....	296	235	310	436	257	249	171	273	265
April.....	301	150	331	474	262	247	169	270	308
May.....	291	435	379	493	265	240	157	270	285
June.....	307	440	445	497	269	233	144	275	250
July.....	299	420	393	508	269	224	145	315	287
August.....	306	488	399	467	269	231	163	310	229
September...	316	510	319	382	266	236	171	309	182
October.....	299	509	303	335	238	234	176	314	189

Wholesale Prices of Ammoniates

	Nitrate of soda bulk per unit N	Sulphate of ammonia bulk per unit N	Cottonseed meal S. E. Mills per unit N	Fish scrap, dried 11–12% ammonia, 15% bone phosphate, f.o.b. factory bulk per unit N	Tankage 11% ammonia, 15% bone phosphate, f.o.b. Chicago, bulk, per unit N	High grade ground blood, 16–17% ammonia, Chicago, bulk, per unit N
1910–14	$2.68	$2.85	$3.50	$3.53	$3.37	$3.52
1926	3.06	2.41	4.40	4.95	4.36	4.90
1927	3.01	2.26	5.07	5.87	4.32	5.70
1928	2.67	2.30	7.06	6.63	4.92	6.00
1929	2.57	2.04	5.64	5.00	4.61	5.72
1930	2.47	1.81	4.78	4.96	3.79	4.58
1931	2.34	1.46	3.10	3.95	2.11	2.46
1932	1.87	1.04	2.18	2.18	1.21	1.36
1933	1.52	1.12	2.95	2.86	2.06	2.46
1934	1.52	1.20	4.46	3.15	2.67	3.27
1935	1.47	1.15	4.59	3.10	3.06	3.65
1936	1.53	1.23	4.17	3.42	3.58	4.25
1937	1.63	1.32	4.91	4.66	4.04	4.80
1938	1.69	1.38	3.69	3.76	3.15	3.53
1939	1.69	1.35	4.02	4.41	3.87	3.90
1940	1.69	1.36	4.64	4.36	3.33	3.39
1941	1.69	1.41	5.50	5.32	3.76	4.43
1942	1.74	1.41	6.11	5.77	5.04	6.76
1943	1.75	1.42	6.30	5.77	4.86	6.62
1944	1.75	1.42	7.68	5.77	4.86	6.71
1945	1.75	1.42	7.81	5.77	4.86	6.71
1946	1.97	1.44	11.04	7.38	6.60	9.33
1947	2.50	1.60	12.72	10.66	12.63	10.46
1948	2.86	2.03	12.94	10.59	10.84	9.85
1949	3.15	2.29	10.11	13.18	10.73	10.62
1950	3.00	1.95	11.01	11.70	10.21	9.36
1951						
November	3.34	2.07	13.93	11.28	10.39	10.25
December	3.34	2.07	14.27	11.28	10.08	10.02
1952						
January	3.34	2.07	14.27	11.28	10.39	12.16
February	3.34	2.07	14.27	11.28	11.61	11.08
March	3.34	2.07	14.26	11.28	9.71	9.04
April	3.34	2.07	14.26	11.28	8.80	8.05
May	3.34	2.07	14.25	11.28	7.75	7.36
June	3.34	2.07	14.27	11.28	8.38	8.38
July	3.34	2.07	14.26	11.28	8.19	7.59
August	3.34	2.07	14.26	11.28	9.78	7.89
September	3.34	2.07	13.39	11.25	11.11	10.02
October	3.34	2.07	13.39	11.24	10.62	9.41
Index Numbers (1910-14 = 100)						
1926	113	84	126	140	129	139
1927	112	79	145	166	128	162
1928	100	81	202	188	146	170
1929	96	72	161	142	137	162
1930	92	64	137	141	112	130
1931	88	51	89	112	63	70
1932	71	36	62	62	36	39
1933	59	39	84	81	97	71
1934	59	42	127	89	79	93
1935	57	40	131	88	91	104
1936	59	43	119	97	106	131
1937	61	46	140	132	120	122
1938	63	48	105	106	93	100
1939	63	47	115	125	115	111
1940	63	48	133	124	99	96
1941	63	49	157	151	112	126
1942	65	49	175	163	150	192
1943	65	50	180	163	144	189
1944	65	50	219	163	144	191
1945	65	50	223	163	144	191
1946	74	51	315	209	196	265
1947	93	56	363	302	374	297
1948	107	71	370	300	322	280
1949	117	80	289	373	318	302
1950	112	68	315	331	303	266
1951						
November	125	73	398	320	308	291
December	125	73	408	320	299	285
1952						
January	122	73	408	320	308	345
February	125	73	408	320	344	315
March	125	73	407	320	288	257
April	125	73	407	320	261	229
May	125	73	407	320	230	209
June	125	73	408	320	249	238
July	125	73	407	320	243	216
August	125	73	407	320	290	224
September	125	73	383	319	330	285
October	125	73	383	318	315	267

Wholesale Prices of Phosphates and Potash **

	Superphosphate, Baltimore, per unit	Florida land pebble, 68% f.o.b. mines, bulk, per ton	Tennessee phosphate rock, 75% f.o.b. mines, bulk, per ton	Muriate of potash bulk, per unit, c.i.f. Atlantic and Gulf ports[2]	Sulphate of potash in bags, per unit, c.i.f. Atlantic and Gulf ports[2]	Sulphate of potash magnesia, per ton, c.i.f. Atlantic and Gulf ports[2]	Manure salts bulk, per unit, c.i.f. Atlantic and Gulf ports[2]
1910–14	$0.536	$3.61	$4.88	$0.714	$0.953	$24.18	$0.657
1926	.598	3.20	5.57	.596	.854	23.58	.537
1927	.525	3.09	5.50	.646	.924	25.55	.586
1928	.580	3.12	5.50	.669	.957	26.46	.607
1929	.609	3.18	5.50	.672	.962	26.59	.610
1930	.542	3.18	5.50	.681	.973	26.92	.618
1931	.485	3.18	5.50	.681	.973	26.92	.618
1932	.458	3.18	5.50	.681	.963	26.90	.618
1933	.434	3.11	5.50	.662	.864	25.10	.601
1934	.487	3.14	5.67	.486	.751	22.49	.483
1935	.492	3.30	5.69	.415	.684	21.44	.444
1936	.476	1.85	5.50	.464	.708	22.94	.505
1937	.510	1.85	5.50	.508	.757	24.70	.556
1938	.492	1.85	5.50	.523	.774	15.17	.572
1939	.478	1.90	5.50	.521	.751	24.52	.570
1940	.516	1.90	5.50	.517	.730	24.75	.573
1941	.547	1.94	5.64	.522	.780	25.55	.367
1942	.600	2.13	6.29	.522	.810	25.74	.205
1943	.631	2.00	5.93	.522	.786	25.35	.195
1944	.645	2.10	6.10	.522	.777	25.35	.195
1945	.650	2.20	6.23	.522	.777	25.35	.195
1946	.671	2.41	6.50	.508	.769	24.70	.190
1947	.746	3.05	6.60	.432	.706	18.93	.195
1948	.764	4.27	6.60	.397	.681	14.14	.195
1949	.770	3.88	6.22	.397	.703	14.14	.195
1950	.763	3.83	5.47	.371	.716	14.33	.195
1951							
November	.820	3.98	5.47	.386	.768	14.72	.193
December	.820	3.98	5.47	.420	.827	16.00	.210
1952							
January	.820	3.98	5.47	.420	.827	16.00	.210
February	.820	3.98	5.47	.420	.827	16.00	.210
March	.832	3.98	5.47	.420	.827	16.00	.210
April	.840	3.98	5.47	.420	.827	16.00	.210
May	.860	3.98	5.47	.420	.827	16.00	.210
June	.860	3.98	5.47	.353	.708	13.44	.176
July	.860	3.98	5.47	.386	.768	14.72	.193
August	.860	3.98	5.47	.386	.768	14.72	.193
September	.860	3.98	5.47	.389	.768	14.72	.193
October	.860	3.98	5.47	.391	.768	14.72	.193
Index Numbers (1910-14 = 100)							
1926	112	88	114	83	90	98	82
1927	100	86	113	90	97	106	89
1928	108	86	113	94	100	109	92
1929	114	88	113	94	101	110	93
1930	101	88	113	95	102	111	94
1931	90	88	113	95	102	111	94
1932	85	88	113	95	101	111	94
1933	81	86	113	93	91	104	91
1934	91	87	110	68	79	93	74
1935	92	91	117	58	72	89	68
1936	89	51	113	65	74	95	77
1937	95	51	113	71	79	102	85
1938	92	51	113	73	81	104	87
1939	89	53	113	73	79	101	87
1940	96	53	113	72	77	102	87
1941	102	54	110	73	82	106	87
1942	112	59	129	73	85	106	84
1943	117	55	121	73	82	105	83
1944	120	58	125	73	82	105	83
1945	121	61	128	73	82	105	83
1946	125	67	133	71	81	102	82
1947	139	84	135	70	74	78	83
1948	143	118	135	67	72	58	83
1949	144	108	128	67	74	58	83
1950	142	106	112	68	75	59	83
1951							
November	153	110	112	70	81	61	82
December	153	110	112	75	87	66	85
1952							
January	153	110	112	75	87	66	85
February	153	110	112	75	87	66	85
March	155	110	112	75	87	66	85
April	157	110	112	75	87	66	85
May	160	110	112	75	87	66	85
June	160	110	112	65	74	56	80
July	160	110	112	70	81	61	82
August	160	110	112	70	81	61	82
September	160	110	112	70	81	61	82
October	160	110	112	70	81	61	82

Combined Index Numbers of Prices of Fertilizer Materials, Farm Products and all Commodities

	Farm prices*	Prices paid by farmers for commodities bought*	Wholesale prices of all commodities†	Fertilizer material‡	Chemical ammoniates	Organic ammoniates	Superphosphate	Potash**
1926	146	150	146	119	94	135	112	86
1927	141	148	139	116	89	150	100	94
1928	149	152	141	121	87	177	108	97
1929	148	150	139	114	79	146	114	97
1930	125	140	126	105	72	131	101	99
1931	87	119	107	83	62	83	90	99
1932	65	102	95	71	46	48	85	99
1933	70	104	96	70	45	71	81	95
1934	90	118	109	72	47	90	91	72
1935	109	123	117	70	45	97	92	63
1936	114	123	118	73	47	107	89	69
1937	122	130	126	81	50	129	95	75
1938	97	122	115	78	52	101	92	77
1939	95	121	112	79	51	119	89	77
1940	100	122	115	80	52	114	96	77
1941	123	130	127	86	56	130	102	77
1942	158	149	144	93	57	161	112	77
1943	192	165	151	94	57	160	117	77
1944	196	174	152	96	57	174	120	76
1945	206	180	154	97	57	175	121	76
1946	234	197	177	107	62	240	125	75
1947	275	231	222	130	74	362	139	72
1948	285	250	241	134	89	314	143	70
1949	249	240	226	137	99	319	144	70
1950	256	246	236	132	89	314	142	72
1951								
November	301	274	259	143	98	343	153	73
December	305	273	258	144	98	342	153	78
1952								
January	300	275	258	144	98	347	153	78
February	289	276	255	146	98	365	153	78
March	288	275	251	144	98	336	155	78
April	290	276	251	142	98	322	157	78
May	293	276	252	142	98	306	160	78
June	292	273	250	141	98	316	160	69
July	295	273	250	141	98	313	160	73
August	295	274	252	144	98	337	160	73
September	288	271	250	145	98	349	160	74
October	282	269	248	145	98	341	160	74

* U. S. D. A. figures, revised January 1950. Beginning January 1946 farm prices and index numbers of specific farm products revised from a calendar year to a crop-year basis. Truck crops index adjusted to the 1924 level of the all-commodity index.

† Department of Labor index converted to 1910-14 base.

‡ The Index numbers of prices of fertilizer materials are based on original study made by the Department of Agricultural Economics and Farm Management, Cornell University, Ithaca, New York. These indexes are complete since 1897. The series was revised and reweighted as of March 1940 and November 1942.

[1] Beginning July 1949, baled hay prices reduced by $4.75 a ton to be comparable to loose hay prices previously quoted.

[2] All potash salts now quoted F.O.B. mines only; manure salts since June 1941, other carriers since June 1947.

**** The weighted average of prices actually paid for potash is lower than the annual average because since 1926 over 90% of the potash used in agriculture has been contracted for during the discount period. The maximum discount is now 16%. Applied to muriate of potash, a price slightly above $.353 per unit K_2O thus more nearly approximates the annual average than do prices based on arithmetical averages of monthly quotations.**

REVIEWS

This section contains a short review of some of the most practical and important bulletins, and lists all recent publications of the United States Department of Agriculture, the State Experiment Stations, and Canada, relating to Fertilizers, Soils, Crops, and Economics. A file of this department of BETTER CROPS WITH PLANT FOOD would provide a complete index covering all publications from these sources on the particular subjects named.

Fertilizers

"Rice Fertilization, Results of Tests From 1946 through 1951," Agr. Exp. Sta., Univ. of Ark., Fayetteville, Ark., Bul. 522, June 1952, R. L. Beacher.

"Influence of Fertilizer Rates on Four Varieties of Flue-Cured Tobacco," Ga. Coastal Plain Exp. Sta., Tifton, Ga., Cir. 22, June 1952, J. M. Carr and I. Neas.

"Barnyard Manure," Ext. Serv., Univ. of Minn., St. Paul, Minn., Ext. Fldr. 168, Aug. 1952, H. E. Jones.

"Influence of Fertilizers on Four Legumes when Grown as Green Manures," Agr. Exp. Sta., Univ. of Minn., St. Paul, Minn., Tech. Bul. 204, June 1952, D. G. Baker, C. O. Rost, and H. W. Kramer.

"Cotton Burs and Cotton Bur Ashes as Fertilizer for Cotton on a Claypan Soil," Agr. Exp. Sta., Okla. A & M College, Stillwater, Okla., Bul. No. B-387, Oct. 1952, H. J. Harper.

"Nitrogen Fertilizers for Rye Cover Crops," Agr. Exp. Sta., Univ. of R. I., Kingston, R. I., Bul. 314, June 1952, J. B. Smith, M. Salomon, and R. M. Beverage.

"Effect of Nitrogen Fertilizer on Yield and Protein Content of Winter Wheat in Utah," Agr. Exp. Sta., Utah State College, Logan, Utah, Bul. 353, June 1952, H. B. Peterson.

Soils

"Chemical Composition of Arkansas Surface Waters 1950," Univ. of Ark., Fayetteville, Ark., July 1952, J. W. Geurin.

"Differential Fixation of Phosphate by Typical Soils of the Hawaiian Great Soil Groups," Agr. Exp. Sta., Univ. of Hawaii, Honolulu, Hawaii, Tech. Bul. No. 16, June 1952, A. C. Chu and G. D. Sherman.

"Characteristics of Irrigation Waters in Idaho," Agr. Exp. Sta., Univ. of Ida., Moscow, Ida., Res. Bul. No. 19, Feb. 1951, M. C. Jensen, G. C. Lewis, and G. O. Baker.

"Soil and Water Conservation and Use," Agr. Exp. Sta., Oreg. State College, Corvallis, Oreg., Oreg. Agr. 9, March 1952.

"Water Quality as it Influences Irrigation Practices and Crop Production . . . El Paso and Pecos Areas," Agr. Exp. Sta., Tex. A & M College, College Station, Tex., Cir. 132, Aug. 1952, P. D. Christensen and P. J. Lyerly.

"The Why, What, and How of Virginia Soil Conservation Districts," Ext. Serv., Va. Poly. Inst., Blacksburg, Va., Cir. 561, Sept. 1952.

"Farming in the Central Sandy Area of Wisconsin," Agr. Exp. Sta., Univ. of Wis., Madison, Wis., Bul. 497, June 1952, P. E. McNall, H. O. Anderson, A. R. Albert, and R. W. Abbott.

"The Great Flood," USDA, Wash., D. C., Agr. Inf. Bul. No. 81, Apr. 1952.

"From the Dust of the Earth," Soil Conservation Serv., USDA, Wash., D. C., Agr. Inf. Bul. No. 78, Mar. 1952, W. H. Lathrop.

Crops

"Silage, Silage Crops, and Silos," Agr. Exp. Sta., Univ. of Calif., Berkeley, Calif., Cir. 411, Apr. 1952, F. L. Smith and L. L. Davis.

"Apricot Culture in California," Agr. Exp. Sta., Univ. of Calif., Berkeley, Calif., Cir. 412, C. O. Hesse.

"Care and Management of Lawns," Ext. Serv., Univ. of Del., Newark, Del., Bul. No. 60, Sept. 1952, C. E. Phillips.

"1951 Chrysanthemum Variety Trial," Agr. Exp. Sta., Univ. of Hawaii, Honolulu, Hawaii, Sta. Prog. Notes No. 79, May 1952, H. Kamemoto and H. Nakasone.

"Irrigated Pastures for Idaho Farms," Ext. Serv., Univ. of Ida., Moscow, Ida., Bul. No. 190, Mar. 1952.

"Green Gold in Idaho," Ext. Serv., Univ. of Ida., Moscow, Ida., Cir. No. 125, Sept. 1952.

"Recommendations for Alfalfa Seed Production in Idaho," Agr. Exp. Sta., Univ. of Ida., Moscow, Ida., Mimeo. Lflt. No. 31, Aug. 1952.

"Seed and Soil Treatments for Prevention of Diseases in Vegetables and Flowers," Agr. Exp. Sta., Univ. of Ida., Moscow, Ida., Mimeo. Lflt. No. 119, R. C. Watson.

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386, July 1952, D. L. Hill and N. S. Lundquist.

"Increasing Farm Production," Ext. Serv., Kans. State College, Manhattan, Kans., Lflt. 18, May 1952.

"Thirty-seventh Biennial Report," Kans. State Board of Agr., Topeka, Kans., Vol. XLII, 1950.

"Grassland Farming on Cutover Pineland of West Louisiana," Agr. Exp. Sta., La. State Univ., Baton Rouge, La., Bul. No. 468, June 1952, H. E. Harris, A. H. McDaniel, and C. B. Roark.

"Good Poultry Pastures for Maryland," Ext. Serv., Univ. of Md., College Park, Md., Bul. 95 (Revised), June 1952, W. H. Rice, G. F. Combs and S. P. Stabler.

"Studies of Factors Affecting the Quality of Green and Wax Beans," Agr. Exp. Sta., Univ. of Md., College Park, Md., Bul. A68, R. B. Guyer and A. Kramer.

"Your Tobacco Experimental Farm," Agr. Exp. Sta., Univ. of Md., College Park, Md., Bul. 443.

"Pasture Feeding of Beef Cattle," Ext. Serv., Univ. of Minn., St. Paul, Minn., Ext. Fldr. 169, Aug. 1952, S. B. Cleland and W. E. Morris.

"Your Agricultural Extension Service, 1951 Annual Report," Ext. Serv., Miss. State College, State College, Miss., Pub. 215 (2M), June 1952.

"1951 Yield Trials with Corn Hybrids in Missouri," Agr. Exp. Sta., Univ. of Mo., Columbia, Mo., Bul. 570, Mar. 1952, M. S. Zuber.

"Performance of New Strawberry Varieties in Missouri," Agr. Exp. Sta., Univ. of Mo., Columbia, Mo., Bul. 576, June 1952, D. D. Hamphill.

"The Chemical Analysis of Grass, Silage, Hay, Straw, Concentrates, and Miscellaneous Feedstuffs," Agr. Exp. Sta., Univ. of Mo., Columbia, Mo., Bul. 579, June 1952, L. D. Haigh.

"Hybrid Seed Corn Production in Missouri," Agr. Exp. Sta., Univ. of Mo., Columbia, Mo., Bul. 580, June 1952, M. S. Zuber.

"Reduced Ascorbic Acid Content of Potatoes Grown with and without Straw Mulching and Irrigation in Eastern Nebraska," Agr. Exp. Sta., Univ. of Nebr., Lincoln, Nebr., *Res. Bul. 170, H. O. Werner, R. M. Leverton, and M. R. Gram.*

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"Forage Grasses for Hay and Pasture I. Smooth Brome Varieties," Agr. Exp. Sta., Univ. of Nev., Reno, Nev., Cir. 1, Apr. 1952, J. H. Robertson.

"Growing Vegetables at Home," Ext. Serv., Univ. of N. H., Durham, N. H., Ext. Bul. 104, Apr. 1952, J. R. Hepler.

"Asparagus in New Hampshire—Its Culture and Uses," Ext. Serv., Univ. of N. H., Durham, N. H., Ext. Bul. 105, May 1952, J. R. Hapler and E. E. Ellis.

Four Native New Mexico Plants of Promise as Oilseed Crops," Agr. Exp. Sta., N. Mex. A & M College, State College, N. Mex., Press Bul. 1064, May 1952, S. Paur.

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"Extension Serves Maine People," Ext. Serv., Univ. of Me., Orono, Me., Ann. Rpt. for year ending June 30, 1952.

"Pastures for Rhode Island," Agr. Exp. Sta., Univ. of R. I., Kingston, R. I., Bul. 313, May 1952, I. H. Stuckey.

"Agricultural Progress in South Carolina 1951, Balancing a Changing Agriculture," Ext. Serv., Clemson Agr. College, Clemson, S. C.

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"Woods Pastures Don't Pay," Ext. Serv., Univ. of Wis., Madison, Wis., Spec. Cir. 30, May 1952.

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Economics

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"Louisiana Farm Production 1909-1951," Agr. Exp. Sta., La. State Univ., Baton Rouge, La., Tech. Bul. No. 467, Apr. 1952, J. P. Montgomery.

"Reducing Dairy Costs on Michigan Farms," Agr. Exp. Sta., Mich. State College, East Lansing, Mich., Spec. Bul. 376, May 1952, C. R. Hoglund and K. T. Wright.

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"Horticulture—An Appraisal of the Problems and a Statement of Recommendations," Ext. Serv., Oreg. State College, Corvallis, Ore., Oreg. Agr. 15, Aug. 1952.

"Grassland Farming," Ext. Serv., Pa. State College, State College, Pa., No. 47, Aug. 1952.

"Opportunities for Farming in South Carolina—Factors to Consider in Selecting a Farm," Ext. Serv., Clemson Agr. College, Clemson S. C., Cir. 376, June 1952, M. C. Rochester.

"Peppermint Production and Marketing," State Dept. of Agr., Madison, Wis., Spec. Bul. No. 9, G. E. Ewald.

"Highlights in the History of Forest Conservation," USDA, Wash., D. C., Agr. Inf. Bul. No. 83, Aug. 1952.

"Citrus Fruits—Production, Farm Disposition, Value, and Utilization of Sales Crop Seasons 1950-51 and 1951-52," USDA, Wash., D. C., Oct. 1952.

"Summary of the Family Farm Policy Review," USDA, Wash., D. C., Sept. 1952.

Big Crop Yields Require Balanced Fertility

BUYING fertilizers without planning for balanced fertility may be a bad investment so far as both increased crop yields and profits are concerned. E. H. Tyner, University of Illinois Soils Fertility Specialist, says that if two or more plant foods are deficient in the soil, the returns from applying fertilizers will depend on how well the balances are maintained.

This principle was clearly demonstrated on fertilizer trial plots in southern Illinois. Both nitrogen and potash were very deficient in the trial area, which produced less than 33 bushels of corn per acre with no treatment. A plot treated with nitrogen alone at the rate of 60 pounds to the acre showed a yield increase of only about three bushels. Another plot was treated with potash alone, at the rate of 120 pounds per acre. Here again the yield increase was small, less than 2½ bushels over the untreated plot. But where the 60 pounds of nitrogen and 120 pounds of potash were both applied, the yield jumped to about 71 bushels, or more than double that of the plot with no treatment.

These results emphasize the fact that applying nitrogen alone on a potash-deficient soil, or potash alone on a nitrogen-deficient soil, does not pay. A good profit can be made only when both of the plant foods are applied to balance fertility. While this experiment involved deficiencies in nitrogen and potash, we could expect similar results in a test involving phosphorus, according to Tyner.

Farmers who depend on legumes for nitrogen don't have to worry too much about poor fertility balance. But the amount of nitrogen fixed by legumes depends on how well the legume grows. If the soil is deficient in lime, phosphate, or potash, there will be less legume growth and less nitrogen will be fixed. So the amount of nitrogen supplied by the legume will generally be in reasonable balance with the mineral supply.

The best quick way to know when a soil has enough lime, phosphorus, and potash, Tyner adds, is to have a soil test made.

Flue-cured Tobacco Fertilizers . . .

(*From page* 26)

quality from Georgia through the Carolinas to Virginia was associated with a decreased use of oilseed meals, such as cottonseed meal, and an increased use of industrial wastes including process tankage.

It has been thoroughly established in extensive field experiments (1,4,5) that water-soluble nitrogen materials are usually better sources of nitrogen for tobacco than even the good-grade organics such as cottonseed meal and animal tankage. The quantity of nitrogen and time of availability to the crop rather than the source of nitrogen influence the yield and quality of the crop.

The study of tobacco fertilizer was extended to include the determination of the quantity of sand and dolomite in the fertilizer. As an average the samples contained approximately 210 pounds of sand and 136 pounds of dolomite per ton of fertilizer.

The studies on the composition of tobacco fertilizer, therefore, give this general picture. A ton of 3-9-6 contains 400 pounds of organic materials of low to medium quality. There are 210 pounds of sand or other inert material. One hundred and thirty-six pounds of dolomite were included to furnish calcium and magnesium and to correct acidity produced by the fertilizer. There remains, therefore, 1,254 pounds of other fertilizer materials that supply all of the phosphorus, all of the potassium, and two-thirds of the nitrogen, as well as substantial quantities of calcium, sulfur, and magnesium. It would be a 3-14-10 fertilizer if not diluted with organics, filler, and dolomite. As indicated in Table I, the fertilizer carries somewhat more phosphorus, calcium, and sulfur than is required by the tobacco crop. In planning new fertilizers, therefore, consideration should be given to the possibility of reducing the amount of phosphorus, calcium, and sulfur. There is good evidence to indicate that if the amount of calcium were reduced it would be easier to increase the potassium content of tobacco leaf and thereby improve its quality. Quality would be further improved by a moderate increase in the potassium content of the fertilizer.

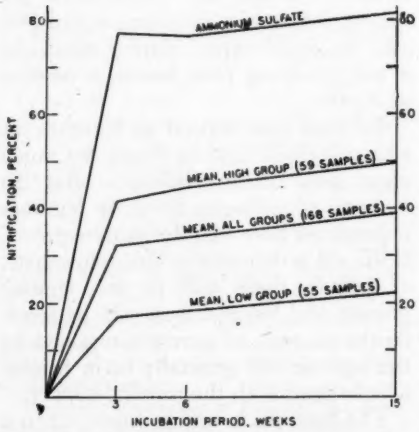

Fig. 2. A comparison of the nitrification in 3-, 6- and 15-week incubation periods at 30° C. of the nitrogen in ammonium sulfate and the water-insoluble nitrogen in mixed fertilizers.

Improved Tobacco Fertilizers

Having considered the nutrient requirements of tobacco, the fertility of tobacco soils, and current fertilizers and fertilizer practices, we are now ready to consider fertilizer improvement. What should the fertilizer furnish the tobacco crop? The amounts of nutrients indicated in Table III would be adequate for the production of 1,500 pounds of high-quality leaf when grown on soils of the fertility indicated by the North Carolina soil-test data. The chief differences between the suggested application and current practice are (a) substantial reductions in the quantity of phos-

TABLE III.—NUTRIENT ELEMENTS REMOVED BY 1,500-POUND CROP AND SUGGESTED AMOUNTS THAT SHOULD BE SUPPLIED BY FUTURE FERTILIZERS (LB. PER ACRE)

Nutrient element	Removed in 1,500 lb. leaf	Supplied by fertilizer	Difference
Nitrogen (N)	33	36	+ 3
Phosphorus (P_2O_5)	7	40	+33
Potassium (K_2O)	50	90	+40
Calcium (CaO)	47	75	+28
Magnesium (MgO)	16	30	+14
Sulfur (SO_3)	21	50	+29
Chlorine (Cl)	30	40	+10

phorus, calcium, and sulfur and (b) a 25-per cent increase in potash. The quantity of nutrients removed in 1,500 pounds of leaf is shown for comparison and the difference for each nutrient is shown in the last column of the table. In each case the quantity suggested for application in the fertilizer exceeds the amount that would be removed in 1,500 pounds of leaf. With the exception of nitrogen and potash, the quantity suggested is greater than the nutrient content of the entire crop as given in Table I.

The indicated quantity of nutrients, or larger amounts, can be supplied by several different fertilizers applied at appropriate rates. Three possibilities are indicated in Table IV and are compared with current practice, 1,200 pounds of 3-9-6 per acre. The comparisons also indicate the quantity of organics, filler, and dolomite in each fertilizer and the relative cost per acre. The latter is estimated from current wholesale cost of fertilizer materials and manufacturing and distribution costs. The three suggested fertilizers, 4-8-10, 5-8-12, and 6-6-15, are formulated with all nitrogen from water-soluble materials. This will increase the efficiency of the nitrogen, reduce costs substantially, and make possible increasing the plant-nutrient con-

TABLE IV.—COMPARISON OF 3-9-6 AND IMPROVED FERTILIZERS OF INDICATED GRADE WITH RESPECT TO NUTRIENTS SUPPLIED, COMPOSITION, AND RELATIVE COST

Nutrient	3–9–6 1200 lb.	4–8–10 900 lb.	5–8–12 720 lb.	6–6–15 600 lb.
	Lb/A	Lb/A	Lb/A	Lb/A
Nitrogen (N)	36	36	36	36
Phosphorus (P_2O_5)	108	72	57	36
Potassium (K_2O)	72	90	86	90
Calcium (CaO)	204	140	116	71
Magnesium (MgO)	24	34	32	40
Sulfur (SO_3)	210	208	66	144
Chlorine (Cl)	36	34	36	36
	Lb/T	Lb/T	Lb/T	Lb/T
Acidity ($CaCO_3$) equiv.	None	None	60	None
Organics	400	None	None	None
Filler	210	220	None	None
Dolomite	136	266	300	500
Relative cost per acre	100	80	70	65

tent of the fertilizer. Each fertilizer would provide 10 pounds of soluble magnesium (MgO) per acre and the recommended quantity of chlorine (Cl).

The 4-8-10 grade, currently recommended in North Carolina, is a very good fertilizer but still provides more calcium, sulfur, and phosphorus than is required. It would normally contain a moderate quantity of filler. Its use will reduce tobacco fertilizer costs about 20 per cent.

The 5-8-12 grade used at the rate of 720 pounds per acre is an excellent and very economical fertilizer. It furnishes the suggested quantity of all plant nutrients with somewhat larger quantities of phosphorus, calcium, and sulfur. All filler would be eliminated but no triple superphosphate would be needed if it were formulated slightly acidic as in the example indicated. The use of the 5-8-12 instead of the 3-9-6 grade would reduce the weight of fertilizer handled on the farm by 40 per cent and would reduce the cost of fertilizer by about 30 per cent.

The 6-6-15 grade furnishes approximately the quantity of all nutrients suggested in Table III but with a considerable excess of sulfur. The phosphorus may be a bit low but this could be corrected by going to a 6-8-15 fertilizer which would give 48 pounds of P_2O_5 per acre. These fertilizers, 6-6-15 or 6-8-15, seem to approach the maximum concentration and economy possible under current fertilizer technology and our existing knowledge of plant requirements and soil fertility. The production of 8-8-20 or 8-10-20 fertilizers to be used at the rate of 450 pounds per acre would be possible if all or a substantial proportion of the dolomite were applied directly to the soil rather than as a constituent of the fertilizer. This would be a major change in practices and should not be adopted until further research has been conducted.

We may anticipate that the 6-6-15 and possibly the 5-8-12 type of fertilizer would be granulated. This would assure excellent physical properties and facilitate accurate distribution and placement of the fertilizer.

It is recognized that introduction of new grades involving use of smaller applications of higher analysis fertilizers will require educational work. However, progress made in use of higher analysis fertilizers for other crops indicates that farmers are willing to accept improved products. Increasing labor and transportation costs and the need for increased efficiency of farm operations are inducements for such changes.

Summary

The plant-nutrient requirements of flue-cured tobacco, the fertility of soils used for its production, and the technology of tobacco fertilizer production have been briefly reviewed. Several fertilizers of increasing concentration, 22 to 29 per cent (N-P_2O_5-K_2O), are suggested as alternatives to the current use of the 3-9-6 grade. The use of the suggested fertilizers would offer the following advantages to farmers:

1. A better fertilizer since all nitrogen is derived from soluble nitrogen materials and more potassium is provided.

2. A reduction in labor, since the rate of fertilization would be reduced from 1,200 to as low as 600 pounds per acre.

3. A reduction of 20 to 35 per cent in the acre cost of fertilizer.

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The Leaf Analysis Approach . . .

(*From page* 14)

The results of leaf analysis surveys have been used to directly correct plant food deficiencies by application of the indicated fertilizer to the crop area determined to be deficient. They have also been very successfully used to locate promising areas for field plot experiments with fertilizers. The leaf analysis data give invaluable preliminary information on plant nutrient levels in the crop and this permits a more intelligent design of the field experiment.

To illustrate the usefulness of leaf analysis surveys in locating deficient areas, the results of a vineyard survey in California can be mentioned. Leaves from 115 vineyards covering a wide area in the State were sampled. In the case of leaf levels of potassium, 23% of the samples showed less than 1% potassium, and 6% of the samples showed less than 0.5% potassium. One of the areas which showed a number of low leaf potassium readings was chosen, and a more intensified survey made. Samples were taken from 135 locations in the area. This intensified survey showed 52% of the samples had leaf potassium levels of less than 1% potassium and 17% of the samples had less than 0.5% potassium. In this manner a localized area of low potassium vineyards was found.

Fig. 5. Apparatus used in obtaining extractions of fresh plant material for analysis. ***(University of California photograph.)***

Identifying Abnormal Symptoms on Plants—The visual symptoms of plant nutrient deficiencies or excesses are not identified or confirmed for all crop plants. Very often certain abnormal leaf symptoms which are not familiar and cannot be identified are seen. If it is suspected that these symptoms are being caused by nutrient deficiency or excess, the chemical analysis of leaf samples can be of great help in explaining the incidence of the symptoms in question.

Many examples are now known where sufficient leaf sampling and leaf analysis of plants with particular leaf symptoms have confirmed these hitherto unidentified symptoms as being those of a plant nutrient deficiency or excess.

Very often, too, certain leaf symptoms characteristic of a nutrient deficiency may be confused with symptoms caused by other influences. Leaf analysis will help to either confirm or reject the nutritional diagnosis.

Acknowledgment

In the preparation of Tables I, II, III, and IV, the author is very grateful for the assistance and counsel given by H. D. Chapman, O. Lilleland, O. A. Lorenz, and Albert Ulrich of the University of California; F. T. Tremblay of Washington State College; J. H. Painter of Oregon State College; F. S. Fullmer and George Wickstrom of American Potash Institute.

The Muellers Conserve Soil . . .

(*From page* 16)

The north part of the farm is steeply rolling and the rest is fairly level bottom land. All sloping land is now being farmed on the contour. They have built one and one-half miles of terraces and diversions and are still building terraces. They have 3,500 feet of waterways and terrace outlets.

One of the finer problems SCS technicians faced in laying out the terrace system was the old family cemetery, now in the middle of a wheat field, where the present owner's grandfather, John Mueller, and his father, George, rest from their labors. By careful calculation, however, the technicians managed to miss the burial ground although a long terrace runs past directly at the south edge of it. The principal grass waterway is 2,000 feet long. It runs at a gentle grade down the cemetery hill to spill excess water into a roadside ditch over a small concrete flume.

The Muellers are using a four-year crop rotation with corn followed by small grains and two years of grass-legume meadow. The entire farm has been limed and fertilized.

Nearly all of the farm land has had 1,500 pounds of rock phosphate and six tons of lime to the acre. Potash has also been applied. For wheat land the Muellers use from 150 to 200 pounds of 4-16-16 or 3-12-12 to the acre. They use fertilizer at corn planting time and also sidedress with 100 pounds of nitrogen to the acre.

This year they will have 30 acres of wheat, 33 acres of soybeans, 38 acres of corn, 16 acres of alfalfa, 12 acres of red clover, 8 acres of grass-legume pasture for the cattle, and 6 acres of ladino pasture for the hogs.

Their normal livestock usually includes 15 or 18 head of beef cattle and 110 head of hogs.

"In the old days before we started modern conservation farming we considered 40 to 50 bushels of corn to the acre as a good crop," Walter Mueller said. "Now we get 75 bushels and one year I had a field that made 81 bushels. We always have plenty of feed for our livestock, and filling in the ditches is a thing of the past. All of our crop yields are up. Wheat usually makes

Fig. 3. A farm pond above the farmstead furnishes water for livestock, recreation, and fire control.

30 to 35 bushels now and in 12 years' time we have made this land more productive than it was in my grandfather's day.

"Farming is easier for us. We save money on machinery repairs and on tractor fuel. It takes less gasoline to pull a plow when you are plowing the land on the level."

One of the latest improvements added by Kenneth Mueller and his father is a fine farm pond just behind the house. From this they have run pipelines which keep a plentiful supply of clean water available for the hogs, the chickens, and the cattle, also fire protection.

When John Mueller bought the 200-acre farm for $250 nearly 125 years ago, the only improvement was a small log cabin. Today there are few farms with better improvements in all of Illinois.

Kenneth W. Mueller, 38 and the fourth generation to till that land, is a quiet, capable individual who guides his tractor around the curving rows as a matter of course. "My father was already farming that way when I started," he explained, "and it's the only kind of farming I have ever done, even though I've been operating the place for more than 10 years now. It's the only way I would want to farm it."

With his wife and their three daughters, Charlene, 11, Marianna, 10, and Cynthia, 6, Kenneth Mueller lives in a fine modern brick farmhouse built in 1935. Here is a perfect setting for gracious rural living.

The barn and other farm improvements are also well above average and

Fig. 4. Kenneth Mueller would have left the farm had not a cure been found for the gullies.

the large modern laying house where 750 white rocks scratch contentedly offers a substantial supplement to the farm income.

Walter Mueller estimates the net income from this farm has been increased 15 to 20 per cent by conservation farming, and adds that his estimate is overly conservative. The fertilizer he puts on his land stays there now. It doesn't wash off into the ditches. His corn yields have jumped 25 bushels to the acre and the erosion problem is under control.

"It's too bad we didn't start doing this 40 years ago," he said, "but of course my father and grandfather didn't have the advantage of the technical assistance which a soil conservation district provides for farmers."

So well sold on the district way of farming was Walter Mueller that after a few years he agreed to run for district director. He served in that office six years. During that period the governing body held 72 meetings and Walter Mueller attended 70 of them.

"Districts are set up to give us true self-government," he explained, "and we have always operated them that way. We made our own decisions. We were always willing to listen to the best advice we could get but the final decision was ours.

"We never got a penny for our travel or any other expense. We felt we were getting enough good out of the district program without it."

The father and son team is also active in Farm Bureau affairs and the elder Mueller has been a member since the local bureau was organized. They have also worked closely with the state Extension Service and have kept farm accounts since 1928.

Proudly displayed on the mantel are two bronze trophies, a cup and a plaque, which the Muellers have won in recent years for their outstanding progress in soil conservation. One is the B. & O. award and the other is a district award.

"Our conservation program is the finest thing that ever happened to this farm," Walter Mueller declared. "It has always been my ambition to leave this land to my only son in a better condition than it was left to me. I believe I have realized my ambition because it's a better farm today than it was when grandfather turned the first furrow.

"I know Kenneth will carry on with this kind of farming because he's convinced it's the only way to operate. In fact most of the progress we've made has been accomplished since he took over active management of the farm 10 years ago.

"It gives me a lot of satisfaction to think that this 200 acres of land has now been home to five generations of Muellers and there is no reason why it can't support five more.

"The story would have been different if we hadn't changed our way of farming though. Because Kenneth would never have put up with low yields and the ditch-filling job my father and I faced every season for so many years. He would have gone to the city just as thousands of other farm boys have done."

Potash Deficiency of Pine and Spruce . . .

(*From page* 22)

Soil samples were taken with a Cenco sampling tube. Each 1-pound composite sample was made up of 15 cores of mineral soil from the plow horizon. The L and F layers were removed before sampling and collected separately.

Soil samples were air-dried and passed through a 1.0-mm sieve.

Tissue samples were dried in a cir-

culating air oven for 4 days at 70°C. The tissue was then ground in a Wiley mill to pass a 1-mm sieve and transferred loosely to a clean glass jar. The jars were then placed in a circulating air oven at 70°C for 3 days and then stoppered tightly with a screw cap cover. The jars were stored at room temperature. Subsequent determinations showed an insignificant uptake of moisture.

The oven-dry tissue was analyzed for percentages of ash, total nitrogen, calcium, potassium, and sodium. Nitrogen was determined by the Kjeldahl method and the metallic elements were analyzed spectrometrically using a Beckman flame photometer (1, 3).

In preparing the samples for spectroscopy 1.000-g samples were ashed in an electric muffle furnace at 530°C for 3-4 hours using "Vycor" silica crucibles. Any residual organic matter was destroyed with concentrated HNO_3, the silica dehydrated by treating with 6*N* HCl, and the ash finally taken up with 2*N* HNO_3, and diluted to 50 ml. Suitable dilutions were subsequently made so that the actual test solutions were in the range of 0-25 ppm for K, 0-50 ppm for Ca, and 0-2.5 ppm for Na. Normality of the standard was adjusted to the same concentration of HNO_3 as the test solution, and a suitable quantity of compensating solution added to each of the standards to provide average concentrations of other cations normally found in the plant tissue being tested. In this study of pine tissue the standard solutions contained compensating amounts of calcium, potassium, magnesium, and sodium in the order of 10:10:2:1 ppm.

The soils were analyzed for pH using the Beckman glass electrode on a soil paste, for total nitrogen by the Kjeldahl method using a 10-g sample, for available potassium and phosphorus by the Truog-Hellige soil test, and for exchangeable potassium by the 1*N* ammonium acetate extraction method of Peech on a 50-g sample (7). The mechanical analyses were determined by the Bouyoucos hydrometer method (2).

The results of the tissue and soil analyses are summarized by species in Table I.

A comparison between the tabulated data and the growth response (Fig. 3) shows a strong correlation between growth response and a high content of K in the needle tissue. The soil from the plots which supported trees with higher contents of K in the needle tissue also contained higher amounts of exchangeable potassium.

Applications of potash-containing substances, including chemical fertilizers as well as natural organic materials such as slash and pine-hemlock humus, resulted in an increase in color, vigor, and growth. In all cases where improved growth resulted from the applications of these materials there was an increase in the potassium content of the needle tissue. The relative value of the "good" slash from healthy stands as compared with the "poor" slash from thinnings in deficient plantations is quite evident in that the "good" slash produced a much stronger growth response and a much greater content of K in the needle tissue.

There was a direct correlation between the amount of potash fertilizer applied and the content of K in the tissue (Fig. 4). The highest rate of application was 300 pounds per acre. Observations of the increase in height increment and general vigor as a result of these comparatively short-term fertilizer trials indicate that the response to a 200-pound per acre application of muriate of potash is similar to the best growth of red pine in natural stands on similar soils. It is significant that the amounts of exchangeable potassium retained in the soil following various rates of potash fertilization were directly proportional to the amounts applied (Table I, 1948 red pine plots).

It is interesting that the K in the needle tissue is concentrated in the needles of the current year's growth,

whereas the Ca content of the needle tissue increases with needle age. It is also noteworthy that the current year's needle tissue from potassium-fertilized and from naturally vigorous trees contains a higher percentage of K than of Ca. This is in direct contrast to the needles from deficient trees where the Ca content of the current needles exceeds the K content.

In the case of the spruces it is premature to suggest minimum contents of K in the needle tissue necessary for satisfactory growth. For *Pinus resinosa* and *P. strobus* it was found that healthy needles of the current year's growth collected during the second and third weeks in September generally contained from 0.45% to 0.74% K whereas the deficient pine had less than 0.34% K in the current needles. On the basis of the results so far obtained, it appears that *Pinus resinosa, P. strobus, Picea glauca,* and *P. abies* may be listed in that order of ascending K requirement; healthy specimens of the more demanding species contain higher amounts of K than the less demanding species, with the converse applying to K-deficient specimens. Field observations have shown that the so-called more demanding species show the deficiency symptoms more strongly.

In spite of the fact that there was some response to $NaNO_3$ fertilization in both the 1943 and 1946 series, the needle tissue from these plots shows no indication of Na uptake above the minimal amounts of Na normally found in coniferous tissue.

There was no great increase of nitrogen in the tissue due to fertilization with nitrogenous fertilizer, and more significantly there was no growth response definitely attributable to nitrogen alone. However, the effect of the heavy slash applications as well as the humus applications was reflected in increased soil nitrogen and some increase in the nitrogen content of the tissue. Although higher contents of nitrogen in the tissue or the soil were not necessarily associated with better growth, in every case an increased amount of K in the tissue was associated with increased growth.

A comparison of the fertility level of the soil from these experimental plantations and the standards of fertility established by Wilde (8) for Lake States nurseries shows that these soils are adequately supplied with total nitrogen, but deficient in available potassium. It should be emphasized that these soils, like most mineral soils, contain an abundant amount of total potassium (1.5-1.8%) which is unavailable in the primary soil minerals. The small amounts of available potassium released through weathering and normally conserved by the humus of the forest soil in exchangeable form apparently have been severely depleted through long agricultural use.

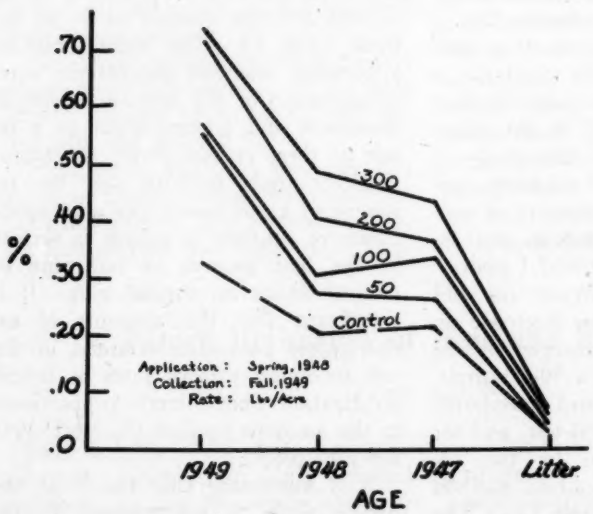

Fig. 4. Potassium content of red pine needle tissue as influenced by rate of KCl application.

TABLE I.—CHEMICAL ANALYSIS OF NEEDLE TISSUE AND SOIL SAMPLES FROM PACK FOREST NUTRITION PLOTS*

Treatment and year	Application Rate	Tissue: Current season's needles N	Current season's needles K	Current season's needles Ca	1 year old needles N	1 year old needles K	1 year old needles Ca	2 year old needles N	2 year old needles K	2 year old needles Ca	Litter K	Soil: Reaction	Soil: Total N	Soil: Exchangeable K
		Percent composition			Percent composition			Percent composition			%	pH	%	ppm
1943		Red Pine (Pinus resinosa)												
CaO	500 #/a	1.20	0.34	0.45	....	....	....	....	....	....	....	5.6	0.154	14.8
$NaNO_3$	300 #/a	1.24	0.29	0.37	....	....	....	....	....	....	....	5.4	0.139	12.8
$(NH_4)_2SO_4$	100 #/a	1.24	0.31	0.45	....	....	....	....	....	....	....	5.3	0.153	13.2
$Ca_3(PO_4)_2$	200 #/a	1.27	0.30	0.36	....	....	....	....	....	....	....	5.2	0.149	12.0
Control		1.10	0.28	0.37	1.16	0.20	0.71	0.95	0.20	0.92	0.03	5.3	0.154	14.4
KCl	200 #/a	1.15	0.49	0.35	1.18	0.27	0.57	1.19	0.26	0.67	0.06	5.3	0.157	22.8
1946														
KCl	200 #/a	1.32	0.62	0.30	1.31	0.39	0.60	1.22	0.41	0.82	0.11	5.5	0.141	18.4
$Ca_3(PO_4)_2$	300 #/a	1.21	0.31	0.42	....	....	....	....	....	....	....	5.5	0.166	17.6
$(NH_4)_2SO_4$	200 #/a	1.26	0.33	0.36	....	....	....	....	....	....	....	5.2	0.171	15.0
Control		1.35	0.33	0.42	1.21	0.21	0.75	1.03	0.22	0.92	0.04	5.3	0.155	16.4
$NaNO_3$	300 #/a	1.36	0.37	0.37	1.23	0.19	0.60	1.23	0.21	0.78	....	5.1	0.157	12.0
K_2SO_4	200 #/a	1.46	0.71	0.38	1.33	0.37	0.87	1.21	0.41	1.08	0.10	5.2	0.155	27.2
Thinned	30%	1.35	0.39	0.35	....	....	....	....	....	....	....	5.5	0.164	14.8
Slash from above		1.16	0.35	0.27	1.21	0.21	0.51	1.19	0.23	0.80	0.05	5.2	0.162	16.9
R.P. Slash	90% coverage	1.51	0.56	0.30	1.34	0.31	0.65	1.15	0.32	0.90	0.07	5.0	0.161	17.5
W.P. Slash	90% coverage	1.56	0.73	0.37	1.28	0.39	0.68	1.10	0.38	0.99	0.09	5.3	0.167	20.4
1948														
KCl	300 #/a	1.35	0.74	0.35	....	0.49	0.59	....	0.44	0.82	0.08	5.2	0.158	26.1
KCl	200 #/a	1.47	0.72	0.44	....	0.41	0.79	....	0.37	1.06	0.07	5.3	0.173	19.7
KCl	50 #/a	1.55	0.56	0.48	....	0.28	0.90	....	0.27	1.17	0.04	5.5	0.173	14.5
KCl	100 #/a	1.40	0.58	0.37	....	0.31	0.75	....	0.34	0.95	0.05	5.2	0.160	16.6
1935														
Humus	2" layer	1.29	0.23	0.25	....	0.16	0.57	....	0.16	0.81	0.05	5.1	0.237	22.5
Control		1.14	0.20	0.42	....	0.16	0.73	....	0.15	1.15	0.04	5.3	0.174	9.4
1937														
5–10–5	500 #/a	....	0.28	0.44	....	0.21	0.76	....	0.21	0.92	....	5.4	0.161	14.1
Control		....	0.22	0.43	....	0.20	0.79	....	0.19	1.02	....	5.5	0.188	12.5
Vigorous healthy trees		1.29	0.50	0.35	....	0.34	0.61	....	0.33	0.71	0.18	5.4	0.241	39.7
1948		White Pine (Pinus strobus)												
KCl	130 #/a	1.88	0.51	0.38	....	0.34	0.87	....	....	....	....	5.5	0.173	27.8
Control		1.63	0.25	0.42	....	0.18	0.96	....	....	....	....	5.5	0.181	11.4
KCl	130 #/a	2.02	0.55	0.39	....	....	....	....	....	....	....	5.2	0.205	28.9
Control		1.62	0.22	0.44	....	0.24	0.98	....	....	....	....	5.5	0.162	10.1
1949		White Spruce (Picea glauca)												
KCl	200 #/a	1.14	0.59	0.66	....	0.41	0.98	....	0.42	1.37	0.07	4.7	0.188	42.3
Control		0.98	0.13	0.45	....	0.11	0.91	....	0.12	1.22	0.05	5.3	0.180	16.7
KCl	100 #/a	1.10	0.35	0.66	....	0.29	0.92	....	0.29	1.14	....	5.2	0.155	21.1
Control		1.02	0.14	0.47	....	0.14	0.94	....	0.15	1.24	....	5.4	0.186	11.8
1949		Norway Spruce (Picea abies)												
KCl	200 #/a	1.14	0.80	0.64	....	0.68	0.99	....	0.66	1.15	0.09	4.6	0.147	33.3
Control		1.07	0.21	0.37	....	0.17	0.75	....	0.18	1.13	0.06	4.7	0.188	15.8

* Oven-dry basis; collected September 10–21, 1949.

Summary

Starvation of young coniferous plantations of *Pinus resinosa, Pinus strobus, Picea abies,* and *Picea glauca* was observed on sandy soils developed on a terrace of glacial outwash in the outskirts of the Adirondack Mountains in New York State. The forest was cleared for agricultural crops and grazing during the period 1800-1850. Fairly intensive agricultural use continued until about 1925. Deficiency symptoms include: 1. General chlorosis followed by browning and finally dying of the needles; 2. Decreased height and diameter growth; 3. Decrease in the number of years that the needles persist on the trees; 4. Shortening of the needles.

Soil mulches of logging debris and forest humus as well as applications of complete commercial fertilizer produced a strong growth response, whereas a glass wool mulch gave no growth response. Applications of CaO, $NaNO_3$, $(NH_4)_2SO_4$, $Ca_3(PO_4)_2$, and KCl as pure chemical salts in May 1943 and 1946 on *Pinus resinosa* plots resulted in a strong growth response to the KCl only, with a mild response to the $NaNO_3$. Subsequent fertilization of symptomatically deficient coniferous plantations including *Pinus strobus, Picea abies,* and *Picea glauca* resulted in a pronounced response of all to potash fertilization even at the end of one growing season.

Chemical analyses of mid-September collected needle tissue showed a strong correlation between increased growth and a high content of K in the tissue. Growth increase was also related to a greater amount of exchangeable potassium in the soil. Current season needles collected from healthy or fertilized *Pinus resinosa* and *Pinus strobus* in September contained from 0.45-0.74% K. In no case did pines which showed deficiency symptoms contain more than 0.34% K in the current needle tissue and usually less than 0.30%. Deficient specimens of *Picea glauca* and *Picea abies* contained even smaller amounts of K, the current tissue analyzing from 0.13-0.21% K.

Trees fertilized with KCl were strongly preferred for food by the varying hare, *Lepus americanus americanus.*

No significant increase of N or Na content of the foliage was found in the pines fertilized with either $(NH_4)_2SO_4$ or $NaNO_3$.

The increase in annual height growth produced by an application of KCl at the rate of 200 lbs. per acre was from 46% to 104% over the control plots, and the effect of the 1943 potash fertilization still continues in the 1949 growth.

In all samples the K was concentrated in the last year's needles, whereas the Ca content of the needles increased rapidly with age. Over a period of years the K content of the foliage of fertilized *Pinus resinosa* is declining slightly, but the effect of fertilization is still manifest in growth and K content of tissue even after a period of 16 years.

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Evergreen Time . . .

(*From page* 5)

better form of government. Gen. Schurz felt that what had been accomplished in the Black Forest and elsewhere in Deutschland might readily be imitated here. It fitted in well with the first national inventory that came out in 1878 by Dr. Hough, reinforced by the rising awareness of observing citizens that here was a real cause for purposeful unity, one that would confer benefits on unborn generations.

The second German to take leadership was Dr. Bernhard E. Fernow, a Prussian forestry expert—probably the first of his kind to enlist the support of the public in this country. He was chairman of the American Forestry Congress that met in Cincinnati in 1882. Four years later Congress created the Division of Forestry, with Dr. Fernow as its chief. Then one year afterward, Massachusetts Agricultural College at Amherst listed the first course of technical forestry lectures ever given in this country, with the same Dr. Fernow conducting them before a large body of students.

Here we have more evidence that America owes something vital to the authorities of the Old World. The experience of the old often helps the careers of the young. Then vigorous youth can repay the debt in the end with return favors. That's the way it has happened. Today we are passing back much so-called "know-how" through various international arrangements. They sent us the original seeds of many of our best crops and flowers. The first rudiments of soil science and many basic elements of animal husbandry and livestock breeding, as well as forest lore, have come to us at critical times from able and experienced foreigners.

If there is any movement for mutual respect and the maintenance of peace and good will that is more influential than an exchange of practical research and experiment, history fails to record it. Without this pioneer aid received at a time when we were abusing our privileges with trees, the progress since seen in that field would have been slower and less effective. Nations which cut themselves off from a free exchange of ideas and methods are only committing slow suicide. All of us will be long enough in the grave without refusing to share with one another in the brief span of time we have to see, and talk, and achieve.

THIS is most significant at Christmas. Christmas is the embodiment of good will and open communication. Like the forest trees that mark its advent and grace its observance, it is up to us to prove that living, vernal spirituality is the finest thing in the world. Forests can be made to restore wasted lands even as the Christian faith took root in a dry and barren land. Green forests can shelter living things and growing plants just as the vibrant meaning of Christmas shelters and comforts the weary and the discouraged. The symbol of Christmas again is one that we derived from overseas, largely from the "Tannenbaum" of the ancient Teutons. To that end the famous Smoky Bear shows us the practical way to be good to our trees, just as we always like to be good to Santa Claus.

In the year we fought and won the war with Spain, the first sparks of a mighty fever for forestry swept into being. As a youngster my memory serves me that my childhood idols of 1898 were Teddy Roosevelt and his Rough Riders and the emergence of another cavalier who coined "conservation" even more ruggedly—Gifford Pinchot. Recruits from the newly established College of Forestry at Cor-

nell University swarmed to the side of Pinchot almost as fast as young soldiers rallied behind Teddy and his "bear," his "Ananias club" and his big stick. In that year there also appeared the first Department of Agriculture farmers' bulletin, entitled "Forestry for Farmers." Forest plans for timberland owners, tree planting, and scientific studies followed when the creation of the Bureau of Forestry occurred in 1901.

Roosevelt and other leaders of the day then urged that all the forest reserves be placed under the jurisdiction of the Department of Agriculture, the first such public reserve created by Congress having been set up in Minnesota in 1902. It was the law of February 1905 that finally transferred all forest reserves to the Forest Service from the Interior Department. There were then about 700 staff members of the Forest Service in Washington and the field. It would not be correct to infer that with this enactment of authority over so much of the public domain there were wholesale cooperation and acquiescence. I have heard old-timers in the service say that when they were in the field it was advisable for them to tote along some shooting irons and dry ammunition. Those were still the days of forest freebooters, and he who stepped on vested interests was in for a battle.

Nevertheless, by 1907 the area of our forest reserve had reached about 107 million acres, with timber sales and grazing permits in the picture. About this time a disapproving element in the Far West got through a crippling rider on the regular agricultural bill. By its terms no more additions could be made by presidential proclamation to the reserves in six or seven states. But here again, Teddy fooled his critics. Three days before the rider became effective he issued 33 proclamations that added about 15 million more acres to the forest sanctuaries. It was also a good time to shift from the President to Congress the power for setting up forest areas under federal control. After this was done the name was made simply "national forests." To call a tract a "reserve" means that it is withdrawn from public use, and the sponsors of the protection of the forests have always figured that unless the public could go into them freely and see their beauty and value, no general clamor for the conservation of timber would be generated.

UNDER this new and better theory, our citizens pour into the vast tree-flung domains by the millions, and use the grazing lands and the waterways to advantage. All they do is to stand for a little police work and regulatory rules during their sojourn in the woods. But the best kind of regulation and protection always consists of a sense of joint ownership and responsibility, the constant adherence to self-control. Although the forest fires have wrecked millions of acres of trees since those early policies were set, a lesser number of them as the years go by are caused by the careless smoking and campfire habits of the outdoors vacationists. In a similar manner, the partnership between cattlemen's societies and the government authorities tends to bring about a gradually improved feeling in regard to sane management of the forest pastures and meadows.

Today the national forests contain about a third of the saw timber this country has. In a few years it is believed the annual cut and sales of timber from these forests will amount to about 10 billion board feet. It was less than 2 billion before World War II. Within the limits of its funds and personnel, the Forest Service is trying hard to protect our wild trees from damage and provide sustained use of all the things that well-managed forests contribute to human welfare.

Sometimes this campaign is a costly and well-nigh terrific job to handle. Too many acres are ravaged with fire and disease despite all our efforts. In

the battle against the dreaded Engleman spruce beetle the most modern weapons of defense seem puny and almost futile sometimes. Gazing at the vast hill slopes in areas infected with this awful scourge, the dead, brown ranks of once mighty trees give an ordinary observer a shuddering preview of the warfare that must go on unceasingly if we are to be blessed with nature's finest products.

But our largest acreages of the remaining native forests are in the hands of private owners. They must furnish the larger share of the annual demand for wood. These privately owned forest tracts in general are not large ones. Fully 260 million acres of the 407 million acres that individuals or corporations own average less than 70 acres each by separate tracts, being owned by over 4 million holders. Farmers own and operate more than half of the privately owned forests.

This brings to the fore the programs that states and associations and farmers' clubs have undertaken to appeal to individual owners to conserve this valuable asset in their own and the community's interest. Naturally, many of these woodlots on farms are badly managed. They get about as much considerate treatment and available labor as the old farm orchards did—and we know well what happened to them in the past 30 years.

Trees and grass to a lot of folks seem like such a natural inheritance that little attention is paid to them as a crop. We are slowly emerging from this era of indifference, however, so that we hear more and more about conserving grasslands and woodlots—both of them mighty forces to put at work to reduce the toll of the flood waters at their sources. But a way must be found to make forest management attractive to the modern commercial farmer. That there is money in the deal has been many times recited with excellent proof and convincing figures. Yet the program is still nebulous and vague in too many spots. There are matters of mechanics and taxation also involved, as well as stubbornness and indifference to combat.

One old farm comes to my mind from long-gone yesterdays of a woods urchin's ramblings. It was a beautiful glade in the oak and maple woods of a Midwest state, with a winding, limpid stream known as the "Ox Bow" flowing through its green bowers. Birds and bees and woods flowers were abundant there, and a charm that is hard to explain existed in that quiet forest tract. Yet now half of the trees are gone and the stream is brown and brackish, showing no trace of the old-time beauty.

Contrasted with that one is another —a wonderful stand of maples covering 50 acres of a dairy farm. Maple sugar making has been done on that tract for nearly 100 years; it is fenced and grazed only with care; suitable selective cuttings are made at times; and often some new trees are planted. The man who owned that forest area knew what a valuable possession he had and governed himself accordingly. Not only that, but he invited classes of young farmers to go into the grove with him and he taught them a few of the simple methods that had been followed through the years for utilizing trees as a real crop instead of a bonanza to be assaulted and demolished for a mess of pottage.

SO here we are again, exchanging ancient greetings as old as the trees with our brethren assembled to celebrate Christmas. Let us fondly hope that the time will never come when our grandchildren must rely upon those artificial dummy, man-made, scraggly imitations of Christmas evergreens. The only way to keep the good and the genuine in life or forestry is to help others get as much enjoyment out of the gospel of conservation as we do—and then practice what we preach all the year.

FREE LOAN OF EDUCATIONAL FILMS

The American Potash Institute will be pleased to loan to educational organizations, agricultural advisory groups, responsible farm associations, and members of the fertilizer trade the motion pictures listed below. This service is free except for shipping charges.

FILMS (ALL 16 MM. AND IN COLOR)

The Plant Speaks Thru Deficiency Symptoms (Sound, running time 25 min. on 800-ft. reel.)

The Plant Speaks, Soil Tests Tell Us Why (Sound, running time 10 min. on 400-ft. reel.)

The Plant Speaks Thru Tissue Tests (Sound, running time 14 min. on 400-ft. reel.)

The Plant Speaks Thru Leaf Analysis (Sound, running time 18 min. on 800-ft. reel.)

Save That Soil (Sound, running time 28 min. on 1200-ft. reel.)

Borax From Desert to Farm (Sound, running time 25 min. on 1200-ft. reel.)

Potash Production in America (Sound, running time 25 min. on 800-ft. reel.)

In the Clover (Sound, running time 25 min. on 800-ft. reel.)

In Canada: The Plant Speaks Thru Deficiency Symptoms
The Plant Speaks, Soil Tests Tell Us Why
The Plant Speaks Thru Tissue Tests
The Plant Speaks Thru Leaf Analysis
Borax From Desert to Farm

DISTRIBUTORS

Northeast: Educational Film Library, Syracuse University, Syracuse 10, N. Y.

Southeast: Vocational Film Library, Department of Agricultural Education, North Carolina State College, Raleigh, North Carolina.

Lower Mississippi Valley and Southwest: Bureau of Film Service, Department of Educational Extension, Oklahoma A & M College, Stillwater, Oklahoma.

Midwest: Visual Aid Service, University Extension, University of Illinois, Champaign, Illinois.

West: Department of Visual Education, University of California, Berkeley 4, California.
Department of Visual Education, University of California Extension, 405 Hilgard Ave., Los Angeles 24, California.
Department of Visual Instruction, Oregon State College, Corvallis, Oregon.
Bureau of Visual Teaching, State College of Washington, Pullman, Washington.

Canada: National Film Board, Ottawa, Ontario, Canada.

IMPORTANT

Requests should be made well in advance and should include information as to group before which the film is to be shown, date of exhibition (alternative dates if possible), and period of loan.

Request bookings from your nearest distributor.

AVAILABLE LITERATURE

The following literature on the use of fertilizers in profitable soil and crop management is available for distribution. We shall be glad to send these upon request and in reasonable amounts as long as our supply lasts.

Circulars

Tomatoes (General)
Asparagus (General)
Vine Crops (General)
Better Corn (Midwest)
The Cow and Her Pasture (General)

Reprints

F-3-40 When Fertilizing, Consider Plant-food Content of Crops
S-5-40 What Is the Matter with Your Soil?
Y-5-43 Value & Limitations of Methods of Diagnosing Plant Nutrient Needs
A-1-44 What's in That Fertilizer Bag?
QQ-12-44 Leaf Analysis—A Guide to Better Crops
P-3-45 Balanced Fertility in the Orchard
Z-5-45 Alfalfa—The Aristocrat
OO-8-45 Potash Fertilizers Are Needed on Many Midwestern Farms
ZZ-11-45 First Things First in Soil Fertility
T-4-46 Potash Losses on the Dairy Farm
Y-5-46 Learn Hunger Signs of Crops
I-2-47 Fertilizers and Human Health
T-4-47 Fertilizer Practices for Profitable Tobacco
AA-5-47 The Potassium Content of Farm Crops
TT-11-47 How Different Plant Nutrients Influence Plant Growth
VV-11-47 Are You Pasture Conscious?
R-4-48—Needs of the Corn Crop
X-6-48 Applying Fertilizers in Solution
AA-6-48 The Chemical Composition of Agricultural Potash Salts
GG-10-48 Starved Plants Show Their Hunger
OO-11-48 The Use of Soil Sampling Tubes
KK-10-49 An Approved Soybean Program for North Carolina
SS-12-49 Fertilizing Vegetable Crops
F-1-50 A Simplified Field Test for Determining Potassium in Plant Tissue
I-2-50 Boron for Alfalfa
K-3-50 Metering Dry Fertilizers and Soil Amendments into Irrigation Systems
O-4-50 Birdsfoot Trefoil—A Promising Forage Crop
V-5-50 Potassium Cures Cherry Curl Leaf
X-5-50 Fertilizers Help Make Humus
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I-2-51 Soil Treatment Improves Soybeans
K-3-51 Increasing Cotton Yields in North Carolina
M-3-51 A Look at Alfalfa Production in the Northeast
O-4-51 More Corn at No Extra Cost
P-4-51 Thirty Tons of Tomatoes per Acre
S-5-51 The Development of the American Potash Industry
W-6-51 Does Potash Fertilizer Reduce Protein Content of Alfalfa?
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CC-10-51 Producing Small Grain More Efficiently
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EE-10-51 Rotation Fertilization
GG-11-51 Fertilizer Recommendations Based on Soil Tests
II-12-51 Pasture Improvement With 10-10-10 Fertilizer
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A-1-52 Research Points the Way to Higher Levels of Peanut Production
C-2-52 Potash Needs Move West
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E-2-52 Ladino Clover—Its Mineral Requirements & Chemical Composition
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H-3-52 The Relative Merits of Inorganic & Organic Sources of Plant Nutrients
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W-8-52 Magnesium and Potassium Nutrition for Sweet Potatoes in the Coastal Plain
X-10-52 The Mineral Uptake by the Sweet Potato

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A lawyer was cross-examining a witness. He asked: "And you say you called on Mrs. White on April 2nd. Now, will you tell the jury what she said?"

"I object to that question," interrupted the other lawyer. There was nearly an hour's argument between the counsel, and finally the judge allowed the question.

"As I was saying," the first lawyer began, "on April 2nd you called on Mrs. White. What did she say?"

"Nothing," replied the witness. "She wasn't home."

* * *

"Why didn't you yell for help when that soldier kissed you?"

"Mother, that soldier didn't need any help."

* * *

Teacher: "Johnny, I'm surprised! Do you know any more jokes like that?"

Johnny: "Yes, teacher."

Teacher: "Well, stay after school."

* * *

After the girl's boy friend had departed, her father called her into the library.

Father—"Daughter, your young man asked for your hand again and I finally consented."

Daughter—"But father, I just can't leave mother."

Father—"That suits me fine. Take her with you."

"Listen," said the cute young thing to her girl friend as she spoke of a rival. "All a sweater does for her is make her itch!"

* * *

A very proper American, who was always exceedingly careful to observe all the proprieties, one day was having dinner with a fat little foreigner, fond of his creature comforts and his family. As the meal progressed, the foreigner suddenly gave out with a resounding burp.

"Oh, my gracious!" said the proper American, aghast. "Are you in the habit of doing this before your children?"

The other shrugged his shoulders:

"Ve have no rules. Sometimes I go first, sometimes de kids go first."

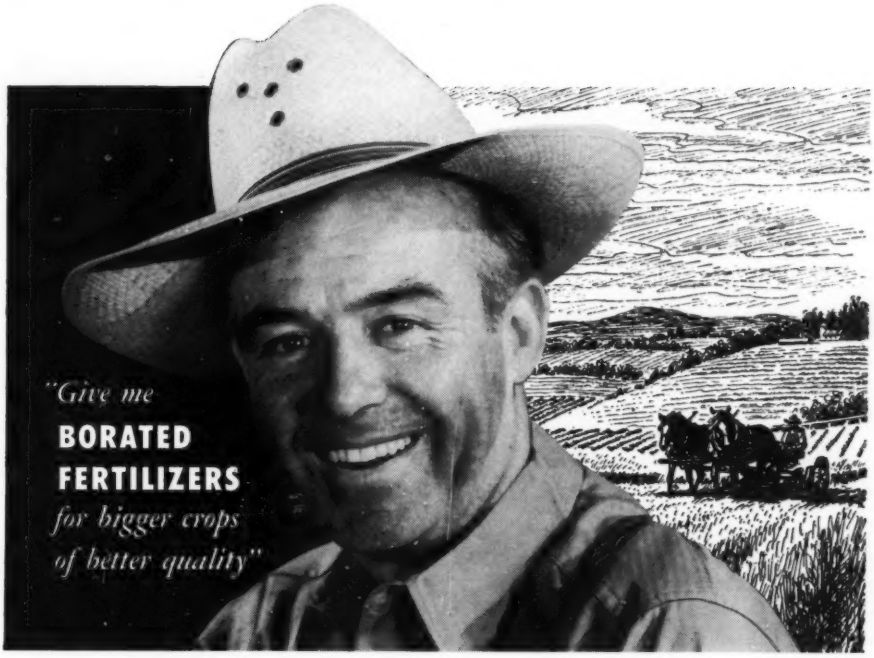
* * *

Short-sighted golfer: "Why didn't you tell me I was hitting a confounded toadstool?"

Caddy: "I never thought you would hit it sir."

* * *

A recruit was on guard duty with specific orders to admit no car unless it bore a special tag. He stopped a tagless car carrying a high-ranking officer. The guard heard the officer order his driver to go right through and calmly the guard spoke up—"I'm new at this, sir; do I shoot you or the driver?"



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FERTILIZER BORATE (*equivalent to approximately 93% Borax*) and FERTILIZER BORATE-HIGH GRADE (*equivalent to approximately 121% Borax*) come in fine mesh for addition to mixed fertilizer, or coarse mesh for direct application where required. This material saves you important money in cost of transportation, storage and handling, etc., because water content is held to approximately 24% water (5 mols). County Agents or State Experimental Stations should be consulted for detailed recommendations. Write today for literature!

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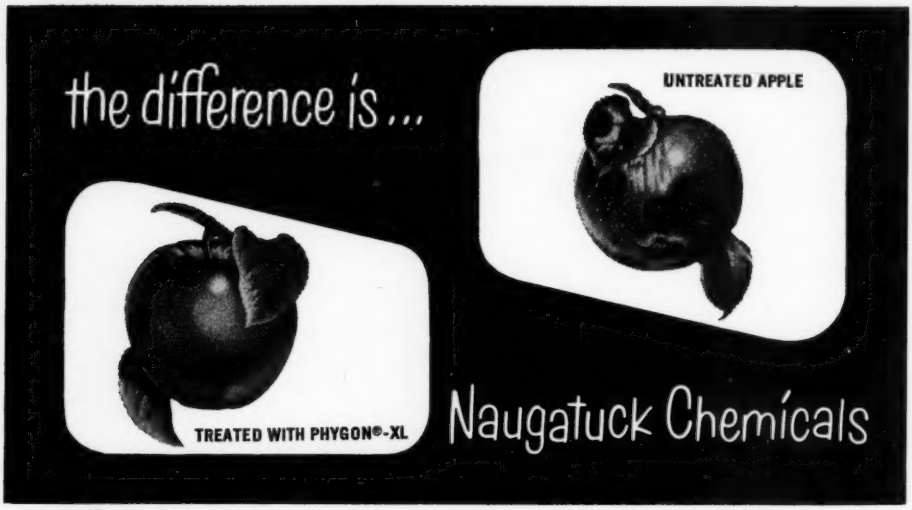

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